691.3
C749
1924

THE CONCRETE YEAR BOOK 1924.

EDITED BY

OSCAR FABER, *O.B.E., D.Sc.*

AND

H. L. CHILDE, *M.J.I.*

CONCRETE SERIES

THE UNIVERSITY

OF ILLINOIS

LIBRARY
691.3
C749
1924

Date Due

15 D 26

8 AP 26

11 OCT 26

6 OCT 26

The person charging this material is responsible for its return to the library from which it was withdrawn on or before the **Latest Date** stamped below.

Theft, mutilation, and underlining of books are reasons for disciplinary action and may result in dismissal from the University.

To renew call Telephone Center, 333-8400

UNIVERSITY OF ILLINOIS LIBRARY AT URBANA-CHAMPAIGN

APR 28 1988

APR 16 1988

L161—O-1096

LIBRARY
UNIVERSITY OF ILLINOIS
URBANA

— THE —
CONCRETE
YEAR BOOK
1924

THE

CONCRETE YEAR BOOK 1924

A HANDBOOK AND DIRECTORY FOR THE CONCRETE INDUSTRY

EDITED BY

OSCAR FABER, O.B.E., D.Sc.

AND

H. L. CHILDE, M.J.I.

(*Editor, Concrete Publications, Ltd.*)

PUBLISHED BY CONCRETE PUBLICATIONS, LTD.

Editorial Office: 35, Great St. Helens, London, E.C.3

Publishing Office: 4, Catherine Street, Aldwych, London, W.C.2

Price 2/6 net; Post Free, 3/-

641.3
C744
1924

FOREWORD.

Among the important industries of the country, the concrete industry has hitherto stood practically alone in having neither a handbook nor a directory prepared specially for its use, and it is to fill this gap that "The Concrete Year Book," of which this is the first edition, has been prepared. In such a large and growing industry there is an obvious need for such works of reference in addition to the many excellent technical books already published, and this is made abundantly clear from the number of inquiries we receive both for information on different aspects of concrete work or as to where such information may be obtained, and for addresses of firms connected with the industry and names of makers of special products.

This publication is intended to supply both classes of information by the inclusion in the volume of (1) a Handbook in which much useful information is given on practical applications of concrete and reinforced concrete, (2) a Directory, and (3) a Catalogue of the industry.

Investigations in concrete and reinforced concrete, and the extended use of the material during recent years, have resulted in well-defined principles being accepted as necessary for the production of the best concrete, and the need for a book giving the results of modern research in brief form and simple language has been felt for some time, and in the Handbook section of this volume we have endeavoured to so present these principles The chapter on "Cement" deals with the characteristics of the material in a non-technical manner, and should serve a useful purpose in enabling all concerned to understand fully the most important element in concrete work. We would draw special attention to the chapter entitled "Essen-

557205

tials in the Production of Good Concrete," which, if the principles and rules embodied therein be carefully followed, will enable anyone to make a first-class concrete at no more cost than a poor one.

Throughout the Handbook section emphasis is placed on the necessity for the employment of the best materials and thoroughly trained workers if the best results are to be obtained. The earlier chapters are, in fact, primarily intended for foremen, clerks of works, and others engaged in similar capacities, on whose knowledge and ability the success or otherwise of the work so much depends. Although there are many excellent foremen engaged in concrete work, and some well-trained workers, the difficulty of obtaining an adequate supply of the skilled supervision and workmanship which is so necessary in reinforced concrete work is perhaps one of the greatest problems the industry has to face to-day ; and it is hoped that the data and hints in this publication will in some measure help to impart to those engaged in the actual execution of the work that knowledge and thorough understanding of the material in which they are working without which the most carefully prepared design may be rendered of little avail.

In other chapters are given specifications for various types of concrete floors, surface treatments, concrete roads, etc., a series of tables for reinforced concrete design, notes on proportioning and grading aggregates to secure the best and most economical results, concreting in cold weather, etc., and memoranda of use in concrete work. In preparing these chapters, which embody the latest practice in this country and abroad, no attempt has been made to put forward individual opinions ; the specifications and methods given are either recognised standard practice or recommendations formulated after thorough investigation by competent bodies. The object has been to make this section a handbook in the true sense of the word ; that is, a book which will be helpful in giving in a concise form data which could otherwise only be obtained by searching text-books and the files of technical journals.

It is proposed to bring the whole of this matter up to date each year, so that every January the researches and developments of the previous year will be available in a handy form. It is, of course, impossible adequately to cover the whole field in each volume, and it is therefore our intention each year to replace certain chapters

with new matter, and to revise thoroughly other chapters so as to bring them into line with current practice and ideas.

A feature of the publication is the "Bibliography of Concrete," in which we have endeavoured to include every book dealing with concrete and allied subjects published in the English language: this chapter will be revised and added to in future editions in order to include new publications. Our thanks are due to the various publishers of technical books for their kind assistance in the preparation of this chapter.

The Directory section has been classified, for ease of reference, under different headings, and we have departed from the usual practice of giving names and addresses only by adding where necessary lists of the products of the different firms. It is hoped that this additional information will be of considerable assistance to those using the directory, and as regards the accuracy of the information we would emphasise the fact that the whole of the contents of this section have been supplied by the firms concerned. Although no pains or expense have been spared in the compilation of this directory in order to make it complete, it is perhaps inevitable that in the first edition of a directory some names may be omitted which should be included; if such is the case, we should be pleased if any person or firm connected with or catering for the concrete industry would communicate with us, in order that they may be included in the 1925 edition.

The Catalogue section is included so that those connected with the industry may have an opportunity of amplifying the necessarily brief particulars in the directory. The value of this section may, we think, be measured by the support it has received from the industry in this first edition, and we would tender our thanks to those who have contributed to the success of this important section of the volume.

December, 1923. THE EDITORS.

CONTENTS.

PAGE

CHAPTER 1.

CEMENT 1
The Setting of Portland Cement—Soundness Tests for Portland Cement—The Storage of Portland Cement—Aluminous and Quick-Hardening Cements—White Cement.

CHAPTER 2.

ESSENTIAL FACTORS IN MAKING GOOD CONCRETE . . . 10
Cement—Tests for Cement—Aggregates—Grading—Water—Workmanship—Atmospheric Conditions—The Setting Time of Concrete—The Density of Concrete and Rodding—The Slump Test.

CHAPTER 3.

PROPORTIONING CONCRETE MIXTURES 25
Effect of Water on Strength.

CHAPTER 4.

STANDARDISATION IN THE PROPORTIONING OF CONCRETE . . 32

CHAPTER 5.

SURFACE TREATMENT OF CONCRETE 48
Exposed Aggregate—Colouring Materials—Rendering—American Methods of Surface Finishing—Cement Washes—Rubbed Finishes—Tooled Finishes.

CHAPTER 6.

CONCRETING IN COLD WEATHER 58

CHAPTER 7.

REINFORCED CONCRETE AND FIRE RESISTANCE . . . 63

CHAPTER 8.

CONCRETE FLOORS 66
Materials—Construction—Reinforced Concrete Floors—Wearing Course—Plain Concrete Floors—Two-Course Plain Concrete Floors—One-Course Floors—Typical Concrete Floor Designs—Unit Stresses—Computation of Quantities of Materials.

PAGE

CHAPTER 9.

CONCRETE ROADS 78
Cost—Materials—Preparation of Subsoil—Concrete—Construction on Marshy Ground—Aggregate—Hardening Concrete Surfaces—The Bates Road Test—Road Accessories—Concrete Kerbing—Integral Kerb—Pavement—Gutters.

CHAPTER 10.

TABLES FOR REINFORCED CONCRETE DESIGN 98

CHAPTER 11.

MEMORANDA FOR CONCRETE USERS 107
Weights and Dimensions of Concrete and its Constituent Parts—Cement—Water—Concrete—Sand and Aggregate—Wheel-barrow—Strength of Concrete at Various Ages—Reinforcement—Proportions of Cement for Concrete—Areas covered by 1 cu. ft. of Cement and Concrete—Proportion of Solids and Voids in Various Coarse Materials—Materials required for Floors per Square Yard—Mortars produced with Ordinary (Fine and Coarse Mixed) Sand—Weights of Various Substances in Lbs. per Cubic Foot—Weight of Square and Round Steel—Materials for 1 cu. yd. of Concrete.

CHAPTER 12.

BIBLIOGRAPHY OF CONCRETE AND REINFORCED CONCRETE . 116

CHAPTER 13.

PROFESSIONAL INSTITUTIONS AND TRADE ASSOCIATIONS . . 125

Directory Section 127
Catalogue Section 187

INDEX TO HANDBOOK SECTION.

	PAGE
Aggregates	13
do. and sand, Tests for	11, 14
do. Broken brick	14
do. Clinker	14
do. Coke-breeze	14
do. Effect of dirty	13
do. for concrete roads	88
do. Grading of	15, 25, 32
do. Proportions of solids and voids in coarse	109
do. surfaces, Exposed	48
do. Weight of	107
Aluminous cement	6
Area covered by 1 cu. ft. of cement and concrete	108
Atmospheric conditions, Effect of	18
Bates road test	90
Bibliography of concrete and reinforced concrete	116
"Bottle" test for cement	12
Brick aggregate, Broken	14
Cement, Accelerated tests for	3
do. Aluminous	6
do. Boiling water tests for	3, 4
do. "Bottle" test for	12
do. British Standard Specification for	2, 4, 8
do. Effect of fine grinding of	5
do. for concrete, Proportions of	108
do. Hardening	11
do. High-pressure steam test for	4
do. Le Chatelier test for	3
do. "Marmalade pot" test for	12
do. Quick-hardening	6
do. Retarded hardening of	10
do. Setting of	2, 11, 19

PAGE

Cement, Soundness tests for 3, 12
do. spoiled by dampness 5
do. Storage of 4
do. Strength of modern 1
do. Strengths of 8
do. washes 54
do. White 9
Channel blocks for roads 91
" Ciment fondu " 6
Clinker aggregate 14
Coke-breeze aggregate 14
Cold weather, Concreting in 58
do. do. Protection during 18
Colouring materials 51
Concrete and its constituent parts, Weights and dimensions of 107
do. at various ages, Strength of 108
do. Materials for 1 cu. yd. of 115
Consistency, " Flow-table " test for 19
Consolidating by rodding 21
do. by vibration 21
Density 20
Design, Tables for reinforced concrete 98–106
Dimensions of concrete and its constituent parts, Weights and 107
Exposed aggregate surfaces 48
Fire resistance, Reinforced concrete and 63
Floor designs, Typical 73–78
Floors, Concrete 66
do. Materials required per sq. yd. for 110
do. One-course 72
do. Plain concrete 70
do. Reinforced concrete 68
do. Two-course 71
" Flow-table " test for consistency 19
Frost, Protection against 18
Grading of aggregates 15, 25
Gutters, Pavement 97
Hardening concrete surfaces 89
do. of cement 11
Insurance, Reinforced concrete and fire 63
Kerb, Integral 97

PAGE

Kerbs, Concrete 91
do. Cost of moulds for concrete 92
do. Moulds for 92
"Marmalade-pot" test for concrete 12
Materials for 1 cu. yd. of concrete 115
do. for 1 cu. yd. of concrete of different strengths, Tables of quantities of 36–47
do. required per sq. yd. for floors 110
Memoranda for concrete users 107
Mixing 16
Mortars produced with fine and coarse mixed sand . . 111
Pavement gutters 97
Permeability 19
Placing concrete 17
Proportioning 25, 32
do. concrete, Standardisation in 32
Proportions for concretes of different strengths, Tables of . 36–47
do. of cement for concrete 108
do. of solids and voids in coarse aggregates . . 109
Protection during cold weather 18
Quantities of materials for 1 cu. yd. of concrete of different strengths 36–47
Reinforced concrete design, Tables for 98–106
Reinforcement, Strength of 108
Reinforcing steel, Weight of 114
Rendering 53
Retarded hardening of cement 10
Road accessories 91
do. finishing, Apparatus for 84
do. surfaces, Hardening concrete 89
do. test, The Bates 90
Roads, Aggregates for concrete 88
do. Construction of concrete 81
do. Cost of concrete 80
do. on marshy ground, Construction of concrete . . 84
Rodding 20
Rubbed finishes 55
Sand and aggregate, Tests for 11, 14
do. Weight of 107
Sea-water and concrete, Effect of 15

PAGE

Setting of Cement 2, 11, 19
Silicate of soda and concrete 89
Slump test 22
Strength of concrete at various ages 108
Surface finishing, American methods of 53
do. treatment 48
Surfaces, Hardening concrete. 89
do. Rubbed 55
do. Tooled 56
Tamper for concrete roads, Hand 84
Test, The Bates road 90
do. The slump 22
Tests for cement, Accelerated 3
do. do. do. Boiling water 3, 4
do. do. do. "Bottle" 12
do. do. do. Hardening 11
do. do. do. High-pressure steam 4
do. do. do. Le Chatelier 3
do. do. do. "Marmalade-pot" 12
do. do. do. Setting-time 2, 11, 19
do. do. do. Soundness 3, 12
do. do. sand and aggregate 11, 14
Vibration, Consolidating by 21
Washes, Cement 54
Water content, Effect of 15, 26
do. on the strength of concrete, Example of influence of 28, 32
do. required for concrete, Approximate quantities of . . 31
do. Weight of 107
Weight of reinforcing steel 114
Weights and dimensions of concrete and its constituent parts 107
do. of various substances 11
Wheelbarrows, Capacity of 107
White cement 9

Index to Directory Section 127
Index to Catalogue Section 187

CHAPTER 1.

CEMENT.

As the binding material on which the strength of concrete primarily depends, too much emphasis cannot be placed on the necessity of care in the selection and handling of cement.

It is indisputable that the quality of the Portland cement on the market to-day is greatly superior to that of twenty or thirty years ago, and it would hardly be exaggeration to state that the modern product has double the strength of its forerunner. It is equally certain that, although there is still much to be learnt by the average user in the employment of concrete aggregates, the cleanliness and grading of the latter now receive more attention than they did in the past. Also, the present generation of contractors' foremen and clerks of works have a better knowledge of concrete and its proper method of production than did their predecessors. As the result of these advances it is right to expect that modern concrete should be a considerably better material than that laid down in 1900 or before, and this expectation is undoubtedly realised. But it is also pertinent to inquire whether full advantage is being taken of the improved concrete of to-day, because if not an opportunity for the national economy that is now of such vital importance is being lost. When we recall certain modern examples of the application of concrete, such as concrete bridges, concrete domes, and concrete skyscrapers, we readily admit that engineers have made full use of the wonderful properties of concrete, but, on the other hand, we doubt whether the bulk of concrete work is being done with that degree of economy which is rendered possible by the improved quality of modern cement.

It is safe to say that a modern concrete is twice as strong as one made twenty years ago with the same proportions and at the same age, but is the possible economy of this improvement being used by reducing the proportion of cement in the concrete or the dimensions of the concrete members ? The cement manufacturer cannot be blamed if he does not recommend his customers to use weaker mixtures ; it is really

beyond his province, and he, quite properly perhaps, contents himself with giving information regarding the strength of his manufactures. There are, however, great possibilities of economy in concrete work if full advantage is taken of the improved standards of modern Portland cement.

It is doubtful whether the degree of precision reached during the past few years in the production of Portland cement has been realised outside the narrow circle of cement manufacturers. Although it must be admitted that the manufacture still has an empirical basis, and there is still some doubt as to the exact chemical compounds present in cement, yet the conditions required to produce a good quality cement are so exactly known that it has become merely a matter of possessing the necessary appliances for a manufacturer to be able to reach and maintain a high standard of quality.

There is no reason why cement made with modern appliances should vary in quality, and the degree of consistency of quality in a Portland cement factory of to-day is remarkable.

THE SETTING OF PORTLAND CEMENT.

The " quickening up " of cement, by which is meant the spontaneous change from a normal slow setting-time to a very quick setting-time, is a difficulty that has caused anxious moments to cement manufacturers and cement users. It has happened that consignments of cement have left cement works with normal setting properties and when put into use some weeks later have been found to set hard in a few minutes. No generally accepted explanation of this change in setting properties has been presented, and although it is an occurrence that now rarely happens, the difficulty has been evaded rather than remedied.

When the reversion to quick setting has taken place it has usually been with a cement which had medium setting properties, viz., final set from thirty minutes to three hours, and the evasion of the difficulty has been helped by the deletion of the " medium setting " grade from the British Standard Specification for Cement. For general use, manufacturers now produce cement with a final set between three and six hours, and with the proper precautions in manufacture there is practically no risk of such a cement becoming quicker setting with time. The abandonment of the medium-setting grade of cement has been no disadvantage, because in the bulk of concrete work the time of setting (so long as it is known) is of small importance compared with the speed of hardening, and this latter property appears to have no connection with setting properties as ascertained by specification tests.

SOUNDNESS TESTS FOR PORTLAND CEMENT.

By the soundness of Portland cement is meant its freedom from expansion other than that caused by increase of temperature or by a change from moist to dry condition. Both of the latter are of such small proportions as to be negligible in constructional work, whereas a cement which is inherently unsound may have expansive properties sufficient to cause disintegration of the concrete containing it or to endanger the stability of a structure in which such concrete is embodied. For example, a concrete floor in which unsound cement is used will either force outward the walls between which it is placed or bulge upward until it cracks.

The damage caused by an unsound cement may be so great that tests for soundness have always been regarded as important, and much discussion has taken place as to suitable tests for the purpose. The most rational test is to prepare bars or cakes of the cement and to ascertain by measurement or observation over periods of months what expansion occurs either in air or water. Such procedure is, however, impracticable owing to the time taken, and consequently various " accelerated " tests have been devised. The basis of " accelerated " tests is the submission of the gauged cement to hot water, and the various methods have ranged from the Faija test at 120 deg. F., the Deval test at 170 deg. F., the boiling water test (212 deg. F.), up to the autoclave test where the cement is heated in steam under pressure to temperatures over 300 deg. F.

All accelerated tests for the soundness of cement are open to the criticism that they are unnatural and that cement is never required in practice to withstand the action of hot water, but they have their basis in the fact of experience that cements which do not crack or swell when heated in water or steam for a short time will not expand in practical usage. There has been much controversy over the temperature required for a reliable soundness test. The Faija test of 120 deg. F. held the field for many years, and there is abundant evidence that this was an adequate safeguard against expansion. The Faija test has become obsolete, not on account of its inadequacy, but because well-manufactured cements will withstand higher temperatures, viz., up to the boiling point of water without swelling or cracking.

Boiling water tests in various forms are now the world-wide standard for cement soundness, but there is no agreement as to the best method of application and there is room for improvement in all. In the Le Chatelier test of the British Standard Specification the gauged cement is put in a mould and immersed in cold water immediately, the boiling

taking place after twenty-four hours. The expansion is measured by means of pointers fixed to the mould, and is the difference between the pointers immediately before and immediately after six hours' boiling. One of the criticisms of the Le Chatelier test is that some of the expansion takes place while the cement is in cold water, and is not measured. The reply given to this is that such expansion is merely the result of the peculiar effect of water upon cement during setting, which has no relation to the real expansion of the cement. Another defect of the test is that the result depends on the setting time of the cement, so that if a quick-setting cement of high expansion is rendered slow setting the expansion becomes reduced, and conversely if the setting time is expedited the expansion increases. The chief value of this test is that it yields its result in an actual measurement.

The boiling or steaming of pats of set cement avoids the interference due to the action of water on the cement during setting, but there is the disadvantage that the result depends upon the individual observer's judgment of what constitutes "warping and cracking," which are the defects leading to condemnation.

The autoclave or high-pressure steam test is generally considered to be unnecessarily severe in its action on cement, and its adoption would probably lead to the production of cements of decreased strength. The strength and the soundness of cement are in some degree opposing factors, because great strength demands a high proportion of lime in the cement while the greater the proportion of lime the greater is the possibility of failure under severe accelerated tests. Hence, an unduly severe accelerated test may demand a lower proportion of lime in cement, which could only lead to a lower strength.

THE STORAGE OF PORTLAND CEMENT.

In a climate like that of Great Britain the storage of Portland cement has never been free from difficulties, and as the cement of to-day is more finely ground than ever the difficulties of storing without damage are increasing. Portland cement has a great avidity for water and will readily absorb moisture from the atmosphere or from damp materials in contact with it. The absorption by cement of 1 per cent. or 2 per cent. of water has no appreciable effect, but further amounts of absorption retard the hardening of the cement and reduce its strength. If the absorption exceeds 5 per cent. the cement is, for all ordinary purposes, ruined. The British Standard Specification for Portland cement recognises the deleterious effect of water in cement by limiting the "loss

on ignition "—an item covering water and carbonic anhydride, but principally the former—to 3 per cent. The more finely a cement is ground the more active it is, and consequently the more rapidly does it absorb moisture from damp surroundings, so that, as previously mentioned, the finely ground modern cements are more susceptible to damage than the cements of twenty years ago. Builders and builders' merchants whose consumption or sale of cement is small, who sometimes are unable to dispose of a consignment of minimum quantity within a month, are particularly liable to loss through damage during storage.

The best method of storage is that adopted by the cement manufacturers, viz., in bulk ; and bins of loose cement 6 ft. or more in depth can lie for longer than a year with no more damage than the formation of a crust on the surface about 2 in. thick, which must be removed before the cement is taken for use. It need hardly be added that the walls and floor of the cement bin must be damp-proof. Hence, if prolonged storage of cement is seen to be unavoidable, it is better to empty it from the sacks and stack it in as deep a heap as possible in a building of which the walls and floor are non-porous, the latter being preferably concrete, or of timber raised from the ground a foot or so with an air-space below.

When cement is stored in sacks absorption takes place from the air through the sack on all sides which are not in contact with other sacks. It is then only a matter of time before sufficient water is absorbed to injure the cement, and it can only be fully realised from experience in the British climate how quickly cement in sacks becomes lumpy and " air-set."

There are some who consider that they have provided perfect storage when the walls, floor and roof of the building are damp-proof, but this idea is held in ignorance of the fact that cement absorbs moisture from the air even when the latter is not perceptibly damp ; nothing but an absolutely air-tight building can be classed as perfect storage.

Indications of damage by storage are given by the cement becoming lumpy, and when this happens the lumps should be screened out unless they are soft enough to be crumbled in the fingers. If cement which has become lumpy is to be used for reinforced concrete or other important work, it is advisable to send a sample to the manufacturers or other expert testers to ascertain whether the strength and setting properties have been seriously affected. When cement is badly damaged it can sometimes be used in the mortar mill for " compo." without incurring the expense of screening out the lumps.

When a building of a temporary character is required for the storage of cement in sacks, the floor can be made damp-proof by constructing it with a double layer of boards with tarred paper between. The walls can also be made damp-proof with one or two layers of tarred paper applied internally, and the roof should be externally protected with tarred felt. For a permanent cement store a concrete building should be considered, but the concrete must be dense to be waterproof and should be allowed to dry out before the building is used. The cement, whether loose or in sacks, should be kept from contact with a new concrete floor by boards. When storing cement in sacks the latter should not be in contact with the outer walls of the building. When sacks of cement are stored several tiers high the pressure upon the lower sacks is sufficient to consolidate the cement, and may give the impression that the cement is air-set. The caking due to consolidation will, however, quickly disappear if the sack is rolled on the floor.

ALUMINOUS AND QUICK-HARDENING CEMENTS.

The advent of the new aluminous cement has stimulated interest in the possibility of improving the quick-hardening properties of Portland cement. There is no doubt that cement users would gladly adopt a quick-hardening Portland cement in preference to a new cement if the hardening properties could be improved to some degree approaching the latter.

Aluminous cement, *ciment fondu*, or electric cement, as it is variously called, possesses the property of rapid hardening, the strength at an age of one or two days being equal to that of Portland cement at twenty-eight days. This cement is composed essentially of aluminate of lime, and in this aspect differs from Portland cement, which is composed for the most part of silicate of lime with only a small proportion of aluminate of lime. The property of hardening rapidly is one of considerable value in certain directions, notably in road repair work, where it is possible to limit the exclusion from traffic to forty-eight hours. For other emergency work this cement will also have advantages, and among other claims it is asserted that piles can be driven three days after moulding.

Concrete users have become so accustomed to waiting for periods of days or even weeks before concrete is sufficiently hard to carry its own unsupported weight or to bear superimposed loads, that it is difficult to envisage the saving in time and economy in procedure that may

result if concrete attains in twenty-four hours the hardness usually developed in a month. Subject to certain considerations, it is possible to foresee remarkable developments in connection with aluminous cements. These considerations are endurance and cost.

There has been no published evidence that aluminous cement maintains its high strength and does not deteriorate with time. Concrete blocks made with this cement a dozen years ago and immersed in sea-water and water impregnated with sulphate are reported to be intact, but apparently the maximum period at which tensile or compression tests have been made is three years, although again it is reported that there is no evidence of retrogression during this period. There is no reason on chemical grounds to suspect deterioration, but it is obvious that engineers must proceed with caution and the new cement will have to stand the test of time before it is regarded unreservedly as a substitute for Portland cement.

The second consideration is that of cost. Aluminous cements require as one of the raw materials an aluminous mineral such as bauxite or corundum, and neither of these is known to exist in England. Hence at the present time aluminous cement is made only in France and Switzerland, and the price in England is double that of Portland cement. Even if manufacture is commenced in England the aluminous raw material will need to be imported, and this will form a substantial addition to the cost of manufacture, which will also have to carry the additional cost of grinding the very hard-fused material to the great fineness that is necessary. However, with an industry still in its infancy, there are doubtless possibilities of cheapening the manufacturing processes. The high price now current will in fact tend to restrict the use of the cement, and thus the caution which we have suggested is necessary will automatically result.

A good deal has been done in recent years by refinements in manufacture, such as fine grinding of raw materials and finished cement, to improve the strength of Portland cement at ages of twenty-four and forty-eight hours, the strengths at these early periods being improved in about the same proportion as the recognised 7-day tests have been improved. But there is still room for further improvement, which would be welcomed by builders and contractors whose operations would be greatly assisted if concrete attained in, say, twenty-four hours the strength usually developed in seven days. Portland cement manufacturers will doubtless be alive to the importance of this matter, and will spare no effort to develop the qualities of cement in this direction. It must be admitted that the British Standard Specification is almost

a deterrent to such an improvement, because of the growth in strength that is demanded for neat briquettes between the ages of seven and twenty-eight days.

The strength of Portland cement is due to the presence of certain definite chemical compounds, and there is probably a definite limit to the tensile and compressive strengths that cement may develop. If by fine grinding the strength is developed at an early period, it is irrational to demand any substantial increase at later dates, especially in the case of neat cements. The British Standard Specification recognises this to some extent by the use of a formula which reduces the required growth from seven to twenty-eight days as the 7-day test increases; but the allowance is not sufficiently effective, and with the personal element in testing tending to cause irregularities there are risks when efforts are made to produce additional strength at early dates that the balance of the strength available in the neat cement will not suffice to yield the increase demanded by the Standard Specification. It must be remembered that the Specification by its stringent tests for soundness and chemical composition already provides safeguards for the ultimate stability of the cement, so that a cement which otherwise complies with the Specification cannot be classed as unreliable if the neat test fails to show the specified increase at twenty-eight days. Hence, as we have already stated, the British Standard Specification is in some degree a deterrent to the development of quick-hardening cements.

In addition, however, to the measure of quick-hardening properties that can be developed by refinements in manufacture there are the same qualities possessed in a superlative degree by some cements as a result of chemical composition. It is known that cements in which the chemical analysis shows the proportion of alumina to be 2 or 3 per cent. above the average are usually considerably better—other conditions being equal—in their early hardening properties than the average cement. Some brands have gained a high reputation among users as the result of their high alumina content endowing the cement with quick-hardening properties. Such cements are seldom if ever the subject of complaint of delayed hardening or failure to set. It is a striking fact that the orthodox Specification tests do not reveal any superiority in quality, and at seven days the tensile and compressive strengths of such quick-hardening Portland cements are no better than the average cement. This has often been a cause of mystification to the user of cement, who observes that while the Specification test of two cements may be similar, yet one cement may "harden off"

much more rapidly than another, and the impression left on the minds of the uninitiated is that tests are of little value.

In the great majority of cases the cement manufacturer is unable to increase the proportion of alumina in his cement at will. The proportion of alumina in the raw materials is usually practically constant in any one deposit, and there is no possibility of increasing this constituent other than by transport of a special raw material at prohibitive cost.

WHITE CEMENT.

White Portland cement is in occasional demand in this country for architectural and decorative purposes, and if the price were lower it is probable the demand would grow. There is no white Portland cement made in the United Kingdom, and the small British requirements are met by imports from the United States, thus accounting for the high price, which includes carriage from the American works to the coast, shipment to English port and storage charges in this country.

White cement differs from ordinary cement only in the proportion of iron oxide it contains, as it is this constituent that gives Portland cement its characteristic grey colour. In white cement the proportion of iron oxide is less than 1 per cent. compared with an average 3 per cent. in the ordinary material. This freedom from iron oxide is obtained by the use of raw materials containing little or none of that constituent, such as, for example, pure limestone and china clay, and in the process of manufacture it is necessary to avoid contamination with iron, especially in the kiln, where oil or specially selected coal must be employed for calcination.

A moderately good imitation of white cement is obtained by choosing a naturally light-coloured Portland cement and mixing it with barium sulphate (barytes) in the proportion of 2 parts cement to 1 part barytes, and in some cases this mixture has produced a shade quite light enough to secure the decorative purpose.

CHAPTER 2.

ESSENTIAL FACTORS IN MAKING GOOD CONCRETE.

THERE are five factors which are important in the production of concrete, viz.—

Cement,
Aggregate,
Water,
Workmanship, and
Atmospheric conditions.

In the following notes the influences of each of these factors are considered in relation to the production of first-class concrete, and it is shown that by the use of right methods the resulting concrete is not only the best but also the cheapest.

CEMENT.*

None other than Portland cement guaranteed to comply with the British Standard Specification should be used in concrete, and if cement buyers made a practice of demanding a certificate of tests from the makers with each consignment they would be in a position to compare the qualities of respective brands and to discriminate in their purchases. Marked improvements have occurred in the quality of British cements of late years, and many brands have double the tensile strength required by the Standard Specification. Provided the setting time and the soundness tests are satisfactory the best cement is that with the highest tensile strength. With cement of high strength it should be possible in many cases to economise not only in the proportion of cement in concrete but in the dimensions of concrete work.

Of the difficulties arising in connection with concrete-laying the most prominent is due to retarded hardening, and the first tendency is to blame the cement as being the only ingredient of the concrete which

* The characteristics of cement, notes on its production, setting, and storage, and soundness tests, are dealt with in Chapter I.

has been the subject of human effort and is, therefore, most susceptible to error. Manufacturers' guarantees and certificates of tests are generally of little avail in such circumstances, and what is needed is an actual demonstration to reveal the qualities or defects of the cement.

Tests for Cement.—The testing of cement is a matter for experts ; the ordinary user of cement has neither the skill nor the apparatus required to ascertain whether a sample of cement complies with the Standard Specification, but without going to the full extent of comprehensive testing there is still room for some common-sense testing which will be useful as a guide and may be the means of avoiding disputes.

It has already been indicated that the most frequent difficulty met with in concrete work is failure to harden in a reasonable time, and the responsibility for this can be determined by a few simple tests within the capabilities of any builder's foreman or bricklayer. To test the setting properties of the cement, about a pound of the cement should be mixed with just sufficient water to produce a stiff paste, and by means of a trowel the paste should be moulded on a piece of iron, slate, or glass into a cake or pat about 3 in. square and 1 in. thick. This pat should be examined from time to time and its progress of setting observed. In 18 or 24 hours the pat should have hardened sufficiently to resist any impression by a thumb-nail; in 48 hours it should not be easy to break the pat in the fingers. This rough and ready test will only be of value if the cement be mixed with the minimum proportion of water into a stiff paste, and if the pat be preserved under cover in a moderately warm room or shed. If the temperature falls below 50 deg. F. the hardening of the cement will be retarded.

If it be proved in this way that the setting of the cement is satisfactory, the next step is to test the effect of the sand and other aggregate in the concrete. It is better to test each individual material separately : about 1 lb. of the cement should be mixed with about 2 lb. of the sand to be tested, and then water added to produce a stiff paste, which should be moulded into a cube-shaped block on a non-porous plate, and the sides smoothed with a trowel. This block should be kept under the conditions described for neat cement testing and should harden at somewhat the same rate. If after 24 or 48 hours the block is not hard there is evidence that the sand is faulty, and methods of discovering the reason for the defect will be described later. If both the cement and sand are proved satisfactory by these tests, a third test should be made with cement, sand, and some of the coarse

aggregate (stone, gravel, broken brick, etc.) to determine the effect of this upon the setting of the concrete. When the cement, aggregate, and water have been proved satisfactory by tests and the concrete work in practice does not harden well, the conclusion must be drawn that the latter experience is the result of severe weather, defective mixing, etc. The effect of the atmospheric conditions can be observed by making duplicate sets of pats and blocks, keeping one set under cover in a warm room and the other set in the open and subjected to the same conditions as the concrete in the work. By this means the possible causes of any unsatisfactory concrete can usually be narrowed down, and when neither cement, aggregate, nor weather can be proved to be harmful there is only workmanship to be blamed.

The neat cement pat previously referred to can be used as a test for soundness or freedom from expansion by boiling the pat in water for a few hours after it has quite hardened in the air. The boiled pat should not soften or crack.

Brief mention may be made here of some of the fallacious tests of cement. The " bottle test " consists in filling a bottle or jar with cement paste and deducing expansion or contraction from the bursting of the bottle or loosening of the cement from the sides of the bottle. This test is misleading because the rates of expansion of glass and cement with rise of temperature differ, and in the great majority of cases when bottles containing set cement crack the cause is not expansion of the cement but unequal expansion and contraction of cement and glass respectively during changes of temperature.

Another fallacious test for cement is the " rise of temperature " test, or " marmalade-pot " test. This test consists in observing the rise in temperature of a paste of cement and water contained in a marmalade pot or other suitable vessel, and a cement is condemned as being " too hot " if the temperature rises during the setting more than 6 deg. F., it being assumed that the warming of the cement paste is due to the slaking of excess or uncombined lime. Since the test was devised it has been proved that the rise in temperature of cement during setting is merely the result of the chemical action of setting, and a high rise indicates a cement of active setting properties, while a small rise shows the cement to be sluggish in setting.

Other tests of a similarly fallacious nature are occasionally met with, but it is safe to say that the only tests of any value that can be carried out in a rough and ready fashion by clerks of works and others on a building job are the setting tests and the boiling test already described. If the results from these are unfavourable the cement should not be

unreservedly condemned, but the manufacturer should be called in and asked to bring evidence, by reference to an independent expert or otherwise, of the quality of the cement.

AGGREGATES.

The following definitions of fine and coarse aggregate taken from the "Tentative Specifications for Concrete Aggregates" issued by the American Society for Testing Materials are as comprehensive as can be wished for and can hardly be improved upon :—

Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains, free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances.

Coarse aggregate shall consist of crushed stone, gravel, or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated pieces free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter.

To approach perfection in concrete clean aggregates are essential, and in this connection dirty aggregates can be classed as those containing loam, clay, and organic matter. The value of cement lies in its property of combining masses of stone together by reason of its adherence to individual grains of sand or pieces of stone, but if the sand or stone is already coated with loam or clay it is obvious that the cement can only come into contact with and adhere to a film of loam or clay, thus making the strength of the concrete depend upon the adhesion between the sand or stone and the covering layer of clay or loam. When concretes containing dirty aggregates are broken up it is frequently found that the pebbles are easily detached from the concrete, and an examination of the surrounding concrete reveals a layer of loam. Another effect of dirty aggregates is that the mud they contain mixes with the cement and prevents the latter from setting and hardening. One of the most frequent causes of complaint concerning concrete is failure to harden, and in most cases the cause is the contamination of the cement with mud from the aggregate. Such complaints are more noticeable in cold, damp weather, because the mud remains in a more or less gelatinous state, but if the concrete can be dried the mud apparently becomes gritty, and in this condition it interferes less with the setting of the cement.

A dirty aggregate can sometimes be detected by rubbing some of

it between the hands and observing the staining effect, but a better test is to stir a handful of the sand or stone in a glass jar with water, when the loam or clay will, on settling, form a layer by itself. If the jar be marked with divisions it is possible to ascertain the proportion of loam in the aggregate by comparing the thickness of the layer of loam with that of the sand or stone. The American specification already referred to limits the amount of clay or loam in sand (material removable by washing) to 3 per cent., but it is perhaps hardly desirable to lay down a rule as to the proportion of loam that is permissible in concrete aggregates, because much depends on the nature of the loam and whether the concrete will be in a warm and dry atmosphere or wet and cold. Some aggregates containing as much as 10 per cent. of loam are used with success, while, on the other hand, the presence of less than 5 per cent. of loam seriously interferes with the hardening in some cases. To be on the safe side, it is advisable to wash all aggregates liable to be dirty, and especially pit sands and ballasts. The latter are subject to great variation as they are dug, and frequent examinations and tests as above are desirable when such aggregates are used.

Sand or gravel containing organic matter (vegetable debris or animal refuse) is particularly objectionable, but there is a simple test for organic matter which can be applied by clerks of works or foremen without difficulty. The test is conducted by shaking some of the sand in a white glass bottle with a 3 per cent. solution of caustic soda, and allowing the mixture to stand for 24 hours. The amount of caustic soda solution used should be such that when in the bottle the bulk of solution should be about equal to the bulk of sand. If after standing for 24 hours the colour of the solution is no more than a pale yellow the sand may be assumed to be free from objectionable organic matter, but if the colour is a marked yellow or brown, the presence of organic matter is indicated, and such sand would not produce a good quality concrete.

Turning to the consideration of artificial aggregates, such as broken brick, clinker, etc., it is of prime importance that such materials should be free from coal or partly-consumed coal, otherwise there is a risk of the concrete expanding after it has set. Coke breeze is largely used as a concrete aggregate with satisfactory results where no great strength is demanded, but here again it is essential that the breeze should contain no coal. With broken brick there is the possible danger of lime being included from adhering mortar or sulphate of lime from "Sirapite" or other plastering, so that broken brick is not safe to use as an

aggregate unless the bricks have been well cleaned. Certain classes of brick made from clay containing pyrites are liable to contain sulphur in an active form, and when this is the case concrete containing such broken brick is liable to swell after setting, especially if in a damp situation. Broken brick is, of course, a porous aggregate, and all porous aggregates (and these include some varieties of stone) should be well soaked with water before use, otherwise they will absorb from the concrete the water required for the setting action of the cement, thus causing imperfect hardening and cracking of the concrete. Some porous aggregates are slow in absorbing water, and it is therefore safer to soak them with water the day before use and again immediately before use.

Grading.—The grading of concrete aggregate, by which is meant the relative sizes of the grains and lumps of which it is comprised, is of great importance. Some American investigators have recently shown that a concrete mix of 8 to 1 can be made as strong as a mix of 6 to 1 by altering the sizes of the sand and stone. (See p. 25.) When fine or dusty aggregate is used an additional quantity of water is required for mixing, and in consequence of this the concrete is weakened. For the best results the proportion of dust or fine material in concrete aggregate should not exceed 10 per cent. as ascertained by sifting the material on a sieve of 50 meshes per linear inch.

In selecting and proportioning the materials for concrete the basis of the operations should be that the proportion of cement should be at least sufficient to fill the voids in the sand, and that the proportion of sand should be that required to fill the voids in the stone. The most economical concrete will, therefore, be that which has the lowest voids in both sand and stone. If stone containing 33 per cent. of voids is obtainable the proportion of sand to stone may be as one to three, and if the voids in the sand are also as low as 33 per cent. the proportion of cement to sand may be as one to three. The theoretical concrete mix with such materials would therefore be 1 : 3 : 9, but as a margin of cement and sand is desirable to allow for uneven mixing, such a mix in practice would be 1 : $2\frac{1}{2}$: 6. If the voids in the sand and stone are less than 33 per cent. the concrete mix could be still weaker without producing an unduly weak and porous concrete, while if the voids are higher, the mix must be richer.

WATER.

The water used for concrete mixing must be clear, and not contaminated with factory or other refuse. Sea water may be used,

although it has a slight retarding effect upon the setting of the cement.

The quality of concrete is, however, usually influenced to a far greater extent by the quantity of water it contains than by the quality of the water. It is easier to make an apparently well-mixed concrete by adding sufficient water to produce a sloppy mixture than to make a well-mixed stiff concrete, and the sloppy mixture is usually placed into position with less labour than the stiff concrete. But these advantages of wet concrete are only obtained at the expense of the finished work, because the strength of concrete depends upon the ratio of water to cement. After a certain point is reached, the more water that is added to concrete the less is its strength. A concrete of 1 part cement to 8 parts sand and stone, mixed with no more water than is needed to produce a plastic mass, will be as strong as one composed of 1 part cement to 6 parts sand and stone if in the latter case the concrete is made wet enough to flow. Hence, by giving the necessary attention and slightly more labour to produce a stiff concrete, it is possible to economise in cement. For concrete foundations, roads, and floors without reinforcement the concrete should be mixed with just sufficient water so that when rammed or punned it combines to form a compact mass. When concrete is required to flow through and under reinforcing bars it must obviously contain more water, and similarly when the concrete is elevated to a height and allowed to flow down chutes into position. The necessity for a more fluid concrete being granted, there should still be some restriction of the proportion of water to the minimum required to produce the necessary fluidity, otherwise there is a risk of the concrete being ruined by segregation of its component parts.

To the builder or contractor doing foundation work, concrete floors, and similar constructions it is impossible to emphasise too strongly the fact that whereas more cement per yard of concrete means greater strength, more water per yard of concrete means less strength. Reduce the water and save the cement is a good maxim.

[The slump test for determining the consistency is described on p. 22.]

WORKMANSHIP.

The one feature in connection with concrete work that is impossible of standardisation is workmanship, and under this heading are included mixing of cement and aggregates, consistency of concrete, and method of deposition. Probably the most frequent example of defective workmanship is seen in the use of too much water for mixing, because this is a means of reducing the labour required for concrete mixing. The

disadvantages of excess water are dealt with in the preceding paragraphs.

Efficiency of mixing of the cement and aggregates is another important factor in the production of concrete. In some carefully-conducted American investigations made a few years ago, it was found that, with all other conditions of testing (including proportion of water) being equal, methods of mixing adopted by various contractors might vary the strength of the concrete produced by as much as 70 per cent.

Except for small jobs, hand-mixing of concrete is becoming out of date on account of the lower cost of machine-mixing. So far as quality is concerned, no concrete-mixer can improve upon the result obtained from systematic and skilful hand-mixing, but really skilled hand-mixing is rare, and there is no doubt that on the average better concrete is produced by mechanical mixing. On the subject of hand-mixing there are various opinions as to the number of times the mixed materials should be turned before and after wetting, but no hard-and-fast rules on this point are desirable because much depends on the method adopted by the man with the shovel. It is better to continue the mixing both before and after wetting until the concrete is homogeneous in appearance and colour.

Speaking generally, concrete mixers of the batch type are more efficient mixers than those of the continuous type. In the batch mixers the materials should remain in the machine for 1½ to 2 minutes, and again a desirable standard of efficiency is that the concrete be homogeneous in appearance and colour. The proposed Standard Specification for concrete in the United States requires that the mixer shall have a peripheral speed of 200 ft. per minute.

A concrete that has been mixed without excess of water requires well punning or "rodding" in position (according to the space into which it is being filled) when being deposited, to secure freedom from cavities. (See p. 20.) The concrete should be finally in position before setting commences, otherwise the hardening will be delayed and possibly permanently injured. Concrete which has partially hardened before it is in position should not be used or mixed in with successive batches. No more concrete should be mixed than can be used before setting commences, and in this connection special care is necessary in hot weather, when the setting may occur in a much shorter period than under normal conditions. Concrete mixed before a meal-time stoppage should not be left until work is resumed before it is deposited in position.

ATMOSPHERIC CONDITIONS.

Concrete attains its best results if it hardens in a warm, damp atmosphere. If the weather is cold and the concrete is exposed to a temperature below 40 deg. F. the rate of hardening is extremely slow; if the concrete be exposed to a hot dry atmosphere while hardening there is danger of the water required by the cement for hardening being evaporated, possibly spoiling the hardening and certainly tending to produce contraction cracks. The view seems to be held by some that concrete hardens by drying out, but with clean aggregates this is not true, and concrete during the first two or three weeks of its existence flourishes in a damp atmosphere. With loamy aggregates it is possible that the weakening effect of the loam is less noticeable as the concrete dries.

All cement generates heat during setting, and if this heat can be conserved in the concrete a satisfactory means of protection against frost is presented. To conserve this naturally-developed heat it is necessary to insulate the concrete, and for this purpose the usual timber shuttering is quite effective; but where there is no shuttering it is not sufficient merely to cover the exposed surface of the concrete with sacks. It is important that there should be no circulation of air over an exposed newly-laid concrete surface during frost, and suitable means of protection are by covering with close boarding, as used for shuttering, or with tarpaulin, so placed as to exclude draughts underneath but to leave a few inches between the concrete and the tarpaulin. For successful concreting in cold weather it is essential that the sand and aggregate should not be mixed in a frozen condition, and if the water used for mixing can be heated to about 80 deg. F., additional protection against frost is provided. As soon as concrete has hardened, there is, of course, no further risk of damage by frost. [Some further notes on concreting in cold weather are given on p. 58.]

The protection of newly-laid concrete from heat and drying winds is as vital as protection against frost. In the first place, cement requires a moist temperature during the first week or two of hardening in order to attain its maximum strength; and second, if the water in concrete dries out while the concrete is new there is danger of the contraction —which is, of course, inevitable when most materials lose water— leading to cracks, because the concrete is not hard enough at an early age to resist without cracking the stresses set up by contraction. The cracks which occur in pipe-joints and in cement plastering are in most cases due to failure to protect the work from too rapid drying. Pipe-

joints can be suitably protected by covering with damp sacks ; timber shuttering is, of course, an adequate protection if left in position for at least a week ; concrete floors or roads should be covered with damp earth or sand for a fortnight after laying, or alternatively kept damp by frequent watering. Plastered vertical surfaces should be protected by tarpaulin and frequently sprayed with water.

The setting of cement is hastened by heat, and when the temperature reaches 80 deg. F. or more in summer and the aggregate and mixing appliances are exposed to the sun, there is a possibility of the cement commencing to set in such a short time that it is difficult to mix and deposit the concrete without disturbing the setting process. There is no remedy for this except to keep the materials, including water, as cool as possible, to demand specially slow-setting cement from the manufacturer, and to expedite the mixing and final deposition of the concrete.

If the above rules and notes are carefully followed, the resulting concrete will be of the best possible quality, and quite impermeable to moisture. The conclusion to be drawn from permeability investigations that have been published is that the rules which must be obeyed to obtain an impermeable concrete are none other than those which govern the production of a satisfactory concrete for any other important purpose, such as road making or reinforced construction. In a few words, the conditions needed are (1) a good cement in the right proportion, (2) a clean and properly graded aggregate, (3) the minimum of water to produce plasticity. [Some notes on hardening concrete surfaces are given on p. 89.]

THE SETTING TIME OF CONCRETE.

Complaint is occasionally made that the setting time of concrete does not bear any definite relation to the setting time of the cement contained in it, and comment on such a statement has hitherto been difficult because of the absence of any method of determining the setting time of concrete. This difficulty has now been removed by the invention of the " flow-table " which was designed primarily for the determination of the " flowability " or consistency of concrete. This apparatus consists of a table about 30 in. diameter mounted on a shaft which, by means of a cam on a horizontal crank shaft, is raised and allowed to drop freely a distance of $\frac{1}{2}$ in. A mass of concrete moulded in the form of a truncated cone 4 in. bottom diameter, 2 in. top diameter and 2 in. high is placed on the table and jolted fifteen times by the method described. The bottom diameter of the mass is then measured, and its relation to the original diameter expresses the degree to which the concrete has flowed.

For determination of setting time, a series of truncated cones is moulded and jolted on the flow-table at intervals, say of one hour or less, until the time arrives when the concrete does not spread or increase in diameter; the period between this time and the time of moulding is said to be the setting time of the concrete.

In some experiments reported to the American Society for Testing Materials it is shown that for a 1 : 1½ : 3 concrete a dry mix set in one and a half hours, a medium mix in three and a quarter hours, and a wet mix in five and three-quarter hours, the corresponding compressive strengths at twenty-four hours being 400 lb., 320 lb. and 185 lb. per sq. in. With a neat cement setting in four and a half hours (according to this apparatus) a 1 : 1½ : 3 concrete set in six hours and 1 : 3 : 6 concrete in seven hours.

THE DENSITY OF CONCRETE AND RODDING.

The materials composing concrete, viz., hydrated cement, sand and gravel or stone, have an average density of about 2·5, and it follows that a concrete of maximum density, i.e., perfectly free from voids, would have a weight per cubic foot of 2·5 × 62·4 lb. = 156 lb. It is to be doubted whether in practice concrete reaches within 10 per cent. of this weight, viz., 140 lb. per cubic foot, thus implying 10 per cent. of voids, which rob the concrete of its strength and impermeability.

It is or should be the aim of all producers of concrete to achieve density, and this is done by several means, notably by using the minimum of water with the concrete and then tamping or rodding to consolidate it, by applying hydraulic pressure as in machine slab-making, by vibration or "jigging" the concrete or by rotation so that centrifugal force comes into play.

Rodding consists of plunging a rod of suitable size into the mass of concrete some twenty times or more, after it has been placed in position. It serves the purpose of consolidating the concrete and of bringing surplus water to the surface, from whence it can be removed.

One example will be sufficient to illustrate the additional strength obtained by pushing a ⅝-in. rod into a cylindrical concrete test-piece (12 in. by 6 in. diam.) about twenty-five times and repeating the operation five times at intervals, allowing surplus water to escape.

	Compressive Strength, Lb. per sq. in.	Weight per cu. ft. in lb.
Rodding once	2,208	147·5
Rodding six times	3,181	150·7

These tests are representative of fifty similar tests with varying mixes and consistencies reported by Giesecke to the American Society for Testing Materials.

Under certain conditions of reinforcement, "rodding" may not be practicable, and then tamping can take its place with the same effect, as shown by Professor Duff Abrams (Bulletin 3, Structural Materials Research Laboratory, Lewis Institute, Chicago), as follows :—

	Compressive Strength. Lb. per sq. in.
Rodding. 25 strokes with $\frac{5}{8}$-in. rod for each 4-in. layer in cylindrical concrete test-piece (12 in. by 6 in. diam.)	2,780
Tamping. 25 strokes with a 2-lb. 2-in. tamper for each 4-in. layer as above	2,800

By the application of pressure to concrete it is possible to work with a dry mix, which of course tends to increased strength, but also, with sufficient pressure, it is possible to expel water from the concrete with a gain in strength. The following examples of the effect of pressure upon the strength of concrete are quoted from Professor Abrams (*loc. cit.*) :—

	Compressive Strength. Lb. per sq. in.
Rodded concrete	2,780
Do. plus pressure of 2 lb. per sq. in.	3,000
Do. do. 50 do.	3,140
Do. do. 100 do.	3,320
Do. do. 200 do.	3,480
Do. do. 500 do.	3,540

Professor Abrams observed that the gain in strength is proportional to the quantity of water expelled, and consequently there is no advantage in maintaining the pressure after water ceases to flow from the concrete.

The vibration or "jigging" of concrete during moulding is only advantageous to strength when dry mixes are used which are difficult to consolidate by hand methods alone, but with a concrete of normal consistency Abrams' experiments show that "jigged" concrete is no stronger than rodded concrete. One attraction of concrete goods moulded on a vibrating table is, however, that the laitance is brought to the upper surface of the concrete during moulding, leaving the lower surface next to the table quite free from this source of weakness and discoloration ; this lower surface can be made the exposed or wearing surface of the concrete in practice.

In connection with the consolidation of concrete by centrifugal force, it is claimed that by rotation of a hand moulded cylinder of 12 in. diameter it is possible to concentrate the concrete so that a hollow central cone of $3\frac{1}{2}$ in. diameter is formed. This implies a reduction in the volume of the concrete of $8\frac{1}{2}$ per cent., equivalent to an increase of about 12 lb. per cub. ft. in weight. During the process of consolidation both air voids and excess water are eliminated so that a dense, strong and impermeable concrete is produced.

THE SLUMP TEST.

In America the slump test for determining the consistency is strongly recommended, and is generally used there. The only apparatus needed is a sheet-metal truncated-cone-shape mould, 12 in. high, 8 in. diameter at the base and 4 in. diameter at the top, provided

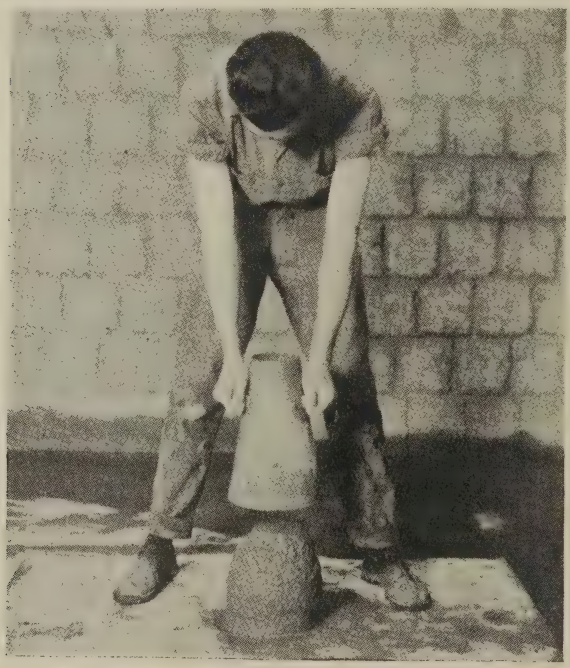


FIG. 1.—MAKING THE SLUMP TEST.

with handles at the sides (see *Fig.* 1), and a $\frac{5}{8}$-in. pointed metal rod 21 in. long. The mould is filled with concrete in layers of 4 in. at a

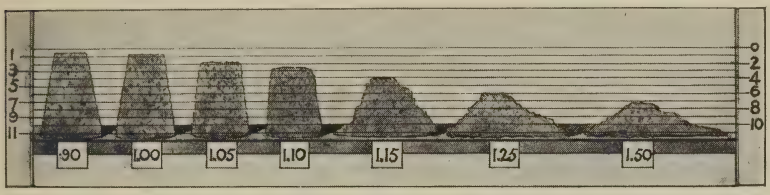


FIG. 2.—RELATION BETWEEN CONSISTENCY AND SLUMP.

(The figures at the sides show the slump in inches. The figures below the specimens indicate the consistency of the piles.)

time, each layer being punned exactly 30 times with the rod. After the third, and last layer, has been punned, the mould is lifted off and the slump measured. Very exhaustive tests undertaken by Professor Duff Abrams at the American Society for Testing Materials have shown that concrete having a slump of from $\frac{1}{2}$ in. to 1 in. will contain only a little more water than is necessary for maximum strength, but will be too stiff for most constructional work; this is called a consistency of 1·00. An increase of 10 per cent. in the water content will give a slump of 3 in. to 4 in., called a consistency of 1·10; an increase of 25 per cent. water gives a slump of 6 in. to 7 in., called a 1·25 consistency; while an increase of 50 per cent. water gives a slump of 8 in. to 10 in., or a consistency of 1·50. *Fig.* 2 shows the relation between the amount of slump in inches and the consistency of the concrete.

The test should be applied to a portion of the first batch of concrete that is mixed, and if the slump is not in accordance with the specification the quantity of water added to the next mix should be altered and the slump again measured, repeating the same procedure on the next batch if necessary. Having arrived at the correct consistency, the test should then be applied several times per day to ensure that the required consistency is uniformly maintained.

A competent inspector or foreman can easily control the quantity of water and, therefore, the strength of the resulting concrete. Each excess pail of mixing water may decrease the strength of concrete as much as if two pails of cement had been left out. The quantity of mixing water must be kept as small as practicable for the class of work being undertaken. The same consistency should be used in all batches.

The Committee on Standard Specifications for Concrete and Rein-

forced Concrete and the American Society for Testing Materials recommend the following slumps for different types of concrete :—

Class of Concrete	Maximum Slumps (ins.).
Mass concrete	2
Reinforced concrete—	
Thin vertical sections	6
Heavy sections	2
Thin confined horizontal sections	8
Roads and pavements—	
Hand finished	4
Machine finished	1
Mortar for floor finish	2

CHAPTER 3.

PROPORTIONING CONCRETE MIXTURES.

The results of some 50,000 tests carried out by the Structural Materials Research Laboratory, at the Lewis Institute, Chicago, under the direction of Professor Duff A. Abrams, to ascertain the most economical concrete mix to produce a given strength, are set out in a Bulletin published by the Institute, from which we take the following :—

The following may be mentioned as among the most important principles which have been established with reference to the design of concrete mixtures.

(1) With given concrete materials and conditions of test the quantity of mixing water used determines the strength of the concrete so long as the mix is of a workable plasticity.

(2) The sieve analysis furnishes the only correct basis for proportioning aggregates in concrete mixtures.

(3) The sieve analysis curve of the aggregate may be widely different in form without exerting any influence on the concrete strength.

(4) Aggregate of equivalent concrete-making qualities may be produced by an infinite number of different gradings of a given material.

(5) Aggregates of equivalent concrete-making qualities may be produced from materials of widely different size and grading.

(6) In general, fine and coarse aggregates of widely different size or grading can be combined in such a manner as to produce similar results in concrete.

(7) The aggregate grading which produces the strongest concrete is not that giving the maximum density (lowest voids). A grading coarser than that giving maximum density is necessary for highest concrete strength.

(8) The richer the mix, the coarser the grading should be for an aggregate of given maximum size ; hence the greater the discrepancy between maximum density and best grading.

(9) A complete analysis has been made of the water-requirements

of concrete mixes. The quantity of water required is governed by the following factors : (*a*) The condition of " workability " of concrete which must be used—the relative plasticity or consistency ; (*b*) the normal consistency of the cement ; (*c*) the size and grading of the aggregate ; (*d*) the relative volumes of cement and aggregate—the mix ; (*e*) the absorption of the aggregate ; (*f*) the contained water in aggregate.

(10) There is an intimate relation between the grading of the aggregate and the quantity of water required to produce a workable concrete.

(11) The water content of a concrete mix is best considered in terms of the volume of the cement—the water-ratio.

(12) The shape of the particle and the quality of the aggregate have less influence on the concrete strength than has been reported by other experimenters.

EFFECT OF WATER ON STRENGTH

Fig. 3 shows the relation between the compressive strength and the water content for 28-day tests of 6-in. by 12-in. concrete cylinders.

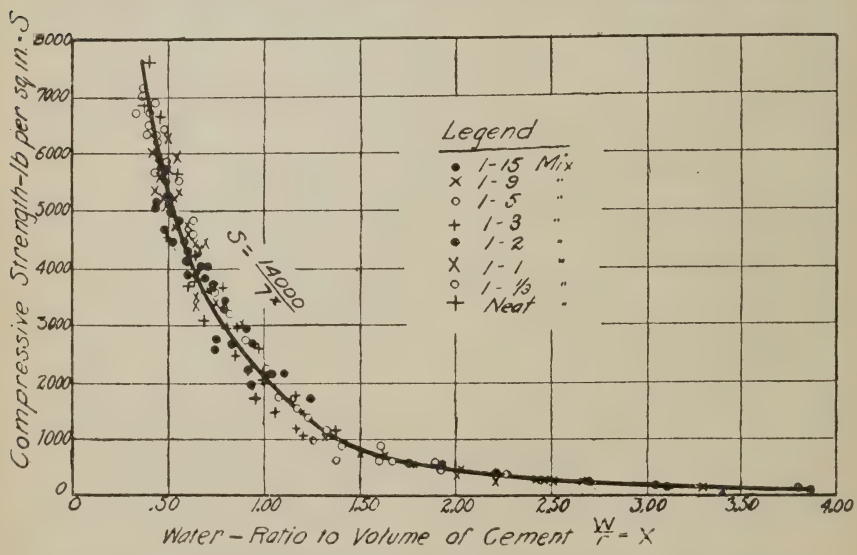


FIG. 3.—RELATION BETWEEN STRENGTH OF CONCRETE AND WATER CONTENT; 28-DAY COMPRESSION TESTS OF 6-IN. BY 12-IN. CYLINDERS.

Mixes from 1 : 15 to neat cement were used ; each mix was made up of aggregates ranging in size from 14-mesh sand up to 1½-in. gravel ; a wide range in consistencies was used for all mixes and gradings. The water content of the concrete is expressed as a ratio to the volume of cement, considering that the cement weighs 94 lb. per cu. ft. Distinguishing marks are used for each mix, but no distinction is made between aggregates of different size or different consistencies.

When the compressive strength is plotted against the water-ratio in this way a smooth curve is obtained, due to the overlapping of the points for different mixes. Values from dry concretes have been omitted. If these were used the result would be a series of curves dropping downward and to the left from the curve shown. It is seen at once that the size and grading of the aggregate and the quantity of cement are no longer of any importance except in so far as these factors influence the quantity of water required to produce a workable mix. This gives an entirely new conception of the function of the constituent materials entering into a concrete mix, and is the most basic principle which has been brought out in our studies of concrete.

The character of the aggregate makes little difference so long as it is clean and not structurally deficient. The absorption of the aggregate must be taken into account if comparison is being made of different aggregates.

The strength of the concrete responds to changes in water, regardless of the reason for these changes. The water-ratio may be changed due to any of the following causes : (1) Change in mix (cement content) ; (2) change in size or grading of aggregate ; (3) change in relative consistency ; (4) any combination of (1) to (3).

In certain instances a 1 : 9 mix is as strong as a 1 : 2 mix, depending only on water content. It should not be concluded that these tests indicate that lean mixes can be substituted for richer ones without limit. We are always limited by the necessity of using sufficient water to secure a workable mix. So in the case of the grading of aggregates. The workability of the mix will in all cases dictate the minimum quantity of water that can be used. The importance of the workability factor in concrete is therefore brought out in its true relation.

The problem of designing concrete mixes resolves itself into this : To produce a workable concrete which has a given water-ratio using a minimum quantity of cement ; or the converse, to produce a workable concrete with a minimum water-ratio using a given quantity of cement. The methods for securing the best grading of aggregate and the use

of the driest concrete which is workable are thus seen to be only devices which enable us to accomplish the above-mentioned results.

The importance of the water-ratio on the strength of concrete will be shown in the following considerations: One pint more water than necessary to produce a plastic concrete reduces the strength to the same extent as if we should omit 2 to 3 lb. of cement from a 1-bag batch. The use of a coarse, well-graded aggregate results in no gain in strength unless advantage is taken of the fact that the amount of water necessary to produce a plastic mix can thus be reduced. In a similar way the use of more cement in a batch does not produce any beneficial effect except from the fact that a plastic workable mix can be produced with a lower water-ratio. The reason a rich mixture gives a higher strength than a lean one is not that more cement is used, but because the concrete can be mixed (and usually is mixed) with a water-ratio which is relatively lower for the richer mixtures than for

EXAMPLE OF INFLUENCE OF QUANTITY OF MIXING WATER ON THE STRENGTH OF CONCRETE.

Values calculated from the equation $S = \frac{A}{B^x} = \frac{14{,}000}{8{\cdot}2^x}$.

Where S = Compressive strength of concrete (lb. per sq. in.).
x = Water-ratio (an exponent).

A and B are constants whose values depend on quantity of cement and other conditions of the test. The values given for A and B are based on 28-day tests of 1 : 4 mix, pebble aggregate graded 0·1¼ in., fineness modulus 5·75.

The water-ratio is equivalent to 1 cu. ft. of water to 1 cu. ft. of cement.

The strength values are solely for comparative purposes in showing the influence of changing the water content.

Water in a 1-Bag Batch		Relative Consistency	Compressive Strength of Concrete at 28 Days	
			Lb. per Sq. In.	Relative Strength
Gallons	Water-Ratio (x)	Per Cent	(S)	Per Cent
5.75	.77	100	2,770	100
6.0	.80	104	2,600	94
6.25	.84	109	2,400	87
6.5	.87	113	2,250	81
7.0	.94	122	1,950	70
7.5	1.01	131	1,670	60
8.0	1.07	139	1,470	53
9.0	1.21	157	1,100	40
10.0	1.34	174	830	30
12.0	1.60	208	480	17
15.0	2.00	260	200	7

1 bag = 1 cu. ft.

FIG. 4.

the lean ones. If advantage is not taken of the fact that in a rich mix relatively less water can be used, no benefit will be gained as compared with a leaner mix. In all this discussion the quantity of water is compared with the quantity of cement in the batch (cu. ft. of water to 1 cu. ft. of cement) and not to the weight of dry materials or of the concrete, as is generally done.

The mere use of richer mixes has encouraged a feeling of security, whereas in many instances nothing more has been accomplished than wasting a large quantity of cement, due to the use of an excess of mixing water. The universal acceptance of this false theory of concrete has exerted a most pernicious influence on the proper use of concrete materials and has proved to be an almost insurmountable barrier in the way of progress in the development of sound principles of concrete proportioning and construction. Rich mixes and well-graded aggregates are just as essential as ever, but we now have a proper appreciation of the true function of the constituent materials in concrete, and a more thorough understanding of the injurious effect of too much water. Rich mixes and well-graded aggregates are after all only a means to an end ; that is, to produce a plastic workable concrete with a minimum quantity of water as compared with the cement used. Workability of concrete mixes is of fundamental significance. This factor is the only limitation which prevents the reduction of cement and water in the batch to much lower limits than are now practicable.

The above considerations show that the water content is the most important element of a concrete mix, in that small variations in the water cause a much wider change in the strength than similar variations in the cement content or the size or grading of the aggregate. This shows the absurdity of the present practice in specifying definite gradings for aggregates and carefully proportioning the cement, then guessing at the water. It would be more correct carefully to measure the water and guess at the cement in the batch.

The grading of the aggregate may vary over a wide range without producing any effect on concrete strength, so long as the cement and water remain unchanged. The consistency of the concrete will be changed, but this will not affect the concrete strength if all mixes are plastic. The possibility of improving the strength of concrete by better grading of aggregates is small as compared with the advantages which may be reaped from using as dry a mix as can be properly placed.

It is impracticable to lay down a general rule for the quantity of water which should be used in a concrete mix, since the total water is

governed by a large number of different factors. However, it is only water which goes to the cement (that is, exclusive of absorbed water) which affects the concrete strength. The failure to recognise this fact has led to many erroneous conclusions from tests carried out with the object of determining the relative merits of different aggregates.

Without regard to the actual quantity of mixing water, the following rule is a safe one to follow : Use the smallest quantity of mixing water that will produce a plastic or workable concrete. The importance of any method of mixing, handling, placing and finishing concrete which will enable the builder to reduce the water content of the concrete to a minimum is at once apparent.

Fig. 5 shows the effect of the quantity of mixing water on the

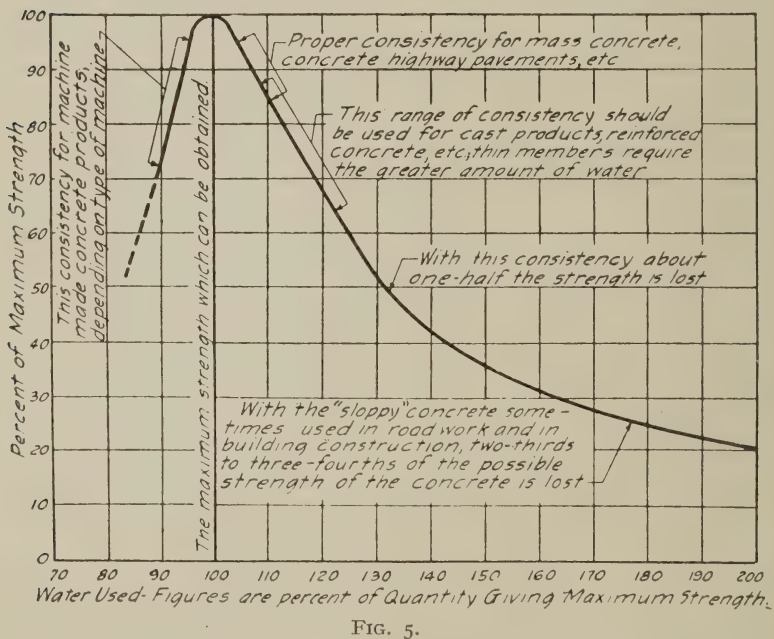

Percent of Maximum Strength
100
90
80
70
60
50
40
30
20
10
0
This consistency for machine made concrete products, depending on type of machine
The maximum strength which can be obtained
Proper consistency for mass concrete, concrete highway pavements, etc
This range of consistency should be used for cast products, reinforced concrete, etc; thin members require the greater amount of water
With this consistency about one-half the strength is lost
With the "sloppy" concrete sometimes used in road work and in building construction, two-thirds to three-fourths of the possible strength of the concrete is lost
70 80 90 100 110 120 130 140 150 160 170 180 190 200
Water Used- Figures are percent of Quantity Giving Maximum Strength.

Fig. 5.

strength of concrete, and is the average of the results obtained from several thousand tests with many different mixings and aggregates at the Lewis Institute, Chicago. Mixtures to the right of the point of maximum strength were plastic ; the others were not plastic. In

general construction work the maximum strength can seldom be obtained because the mixture would be too stiff to be workable, but from 70 per cent. to 90 per cent. of the maximum strength can be readily obtained. It is pointed out that a great deal of strength is lost when concrete blocks are made semi-dry, and that a much greater strength would be obtained if a wetter mix were used and the concrete left in the moulds longer. Approximate quantities of water applicable to usual conditions are given in *Fig.* 6.

Mix		Approximate Mix as Usually Expressed			Water Required (Gallons per sack of Cement)	
			Aggregate			
Cement	Volume of Aggregate After Mixing	Cement	Fine	Coarse	Minimum	Maximum
1	3	1	1¼	2½	5	5½
1	4	1	1½	3	5½	6
1	4½	1	2	3	5¾	6¼
1	5	1	2	4	6	6½
1	6½	1	2½	5	7¼	7¾
1	7¾	1	3	6	8¼	8¾

1 sack = 1 cu. ft.

FIG. 6.—APPROXIMATE QUANTITIES OF WATER REQUIRED FOR CONCRETE.

CHAPTER 4.

STANDARDISATION IN THE PROPORTIONING OF CONCRETE.

On pages 36 to 47 are given some tables for the proportioning necessary to produce concretes of different compressive strengths, ranging from 1,500 lb. per sq. in. to 4,000 lb. per sq. in. These tables are the result of a very large and comprehensive series of tests undertaken at the Structural Materials Research Laboratory of the Lewis Institute, Chicago, by Mr. Duff Abrams (Professor in Charge of the Laboratory), and Mr. Stanton Walker (Associate Engineer), and are reprinted from Bulletin No. 9 of the Laboratory.

In an introduction to the tables the authors state: "The most striking features of the experiments on which these tables are based are that they bring out the fundamental relations between the quantity of mixing water and the quality of the resulting concrete, and show that the size and grading of the aggregate and the quantity of cement affect the strength of concrete only in so far as they influence the water requirements. These investigations have shown that the interrelation of strength and proportions of materials may be expressed by the following principles:

"1. The strength of a concrete mixture depends on the quantity of mixing water in the batch, expressed as a ratio to the volume of cement so long as the concrete is workable and the aggregates are clean and structurally sound. The strength of the concrete decreases as the water-ratio increases.

"2. The effect of differences in the quantity of cement is reflected by differences in the water-ratio. In richer mixtures, a given condition of workability can be produced with a lower water-ratio, and consequently give higher strengths.

"3. There is an intimate relation between the size and grading of the aggregate and the quantity of water required to produce concrete of a given workability. The strength of concrete is affected by the size and grading of aggregate only in so far as the quantity

of mixing water is influenced by these variables, so long as the aggregate is not graded too coarse for proper workability. Finer aggregates require more water for a given plasticity and quantity of cement and therefore give lower strengths than the coarser aggregates.

" 4. It is not necessary, or desirable, that the aggregate be proportioned according to any fixed grading ; wide variations in gradings of aggregate may occur without affecting the quantity of mixing water or the quality of the concrete. The classification of all aggregate finer than $\frac{1}{4}$ in. as fine aggregate, and that above this size as coarse aggregate, is purely an arbitrary division. Aggregates separated into any sizes may be proportioned to give desired results, so long as the grading will give workable concrete. The separation of aggregates into two sizes is desirable to facilitate uniform proportioning of successive batches.

" 5. Plasticity or workability is an essential requirement of concrete for structural purposes. If a high degree of workability is necessary, this factor must be taken into account in designing the mixture. It is essential that the workability be kept under proper control.

" Any combination of the constituent materials which produces concrete of a given water-ratio will result in concrete of approximately the same strength, so long as the concrete is workable. The foregoing statements embody the essential features of what has become known as the water-ratio theory of proportioning concrete. A casual examination of the tables will show the vital influence of the quantity of mixing water, by the differences in quantities of materials required for different conditions of workability, as indicated by the slump test. The effect of what may seem slight changes in the quantity of mixing water has been generally overlooked in earlier discussions of this subject."

The tables are intended to be applied for the following purposes to all types of concrete work in which plastic mixtures may be used :

1. To furnish a guide in the selection of mixtures to be used in preliminary investigations of the strength of concrete.

2. To indicate proportions which may be expected to produce concrete of a given strength under average conditions where control tests are not made.

3. To furnish a basis for comparing the relative economies of concretes made by combining aggregates of different sizes, when the workability and strength of the resulting concrete are taken into account. (In other words, it is not necessary to restrict aggregate sizes to those usually mentioned in specifications.)

4. To furnish a basis for making changes in proportion to compensate for variations in size and grading of aggregates or workability of the concrete during the progress of the work.

The tables are based on the following considerations :

1. The compressive strength of concrete at 28 days, tested in accordance with standardised methods, is taken as the basis of quality of concrete.

2. The essential features of the method of testing are :

a. Aggregates of known sieve analysis.
b. Aggregates in room-dry condition.
c. Unit volumes determined by standard methods.
d. Cement assumed to weigh 94 lb. per cu. ft.
e. Proportions by volume.
f. Hand-mixed concrete puddled in 6 by 12 in. cylinder forms.
g. Concrete cured in moist place until tested.
h. Tests made at age of 28 days.
i. Each value based on 5 or more specimens made on different days.

3. Studies of the average interrelation of strength of concrete, size and grading of aggregate, quantity of cement and quantity of mixing water for the range covered by these tables.

4. Selection of sieve analyses of aggregate to represent average of materials of size-classification shown.

5. Determination of the most economical proportions of fine and coarse aggregates for each of the other conditions.

6. Yield of concrete determined by measurements and weights of 6 by 12 in. cylinders.

PRECAUTIONS IN THE USE OF THE TABLES.

The following precautions to be observed in the use of tables are given :—

1. If the proportions to be used in the work are selected from the tables, without preliminary tests of the materials, and control tests are not made during the progress of the work, the mixtures in bold-faced type should be used.

2. Strengths were based on 28-day compression tests of 6 by 12-in. concrete cylinders puddled in the forms, cured in a damp place at normal temperatures and tested in a damp condition. Allowance must be made for lower strength resulting from temperatures below normal.

3. Portland cement should meet the requirements of the standard specifications.

4. Aggregate should be clean, structurally sound, and graded in size between the limits shown in the tables.

5. Concrete should be mixed at least 1 minute in a batch mixer of approved design.

6. In comparing the strengths of concrete specimens made on the work with the values in the tables, it is important that tests be made in accordance with standard methods.

7. The quantities of materials were based on measurements in the laboratory, using dry materials rodded or puddled into the measure. No allowance was made for waste.

8. The slump test should not be too strictly interpreted.

9. Proportions and quantities of materials may be interpolated for concrete strengths, aggregate sizes, and consistencies not covered by the tables.

[In the tables giving the quantities of materials required to produce concrete of a given strength, it should be noted that the standard American barrel contains 376 lb. or four bags of 94 lb. each.]

Proportions for 1,500 lb. per sq. in. Concrete.

[Based on 28-day compressive strength of 6 by 12 in. cylinders. Proportions are expressed by volume as follows: Portland cement: fine aggregate: coarse aggregate—Thus 1 : 2·6 : 4·6 indicates 1 part by volume of Portland cement, 2·6 parts by volume of fine aggregate, and 4·6 parts by volume of coarse aggregate.]

Size of Coarse Aggregate	Slump, in.	Proportions Using Fine Aggregate of Different Sizes				
		0-No. 30	0-No. 16	0-No. 8	0-No. 4	0-⅜ in.
None	½ to 1	1:2.8	1:3.2	1:3.8	1:4.4	1:5.1
	3 " 4	1:2.4	1:2.8	1:3.3	1:3.8	1:4.5
	6 " 7	1:1.9	1:2.2	1:2.6	1:3.0	1:3.6
	8 " 10	1:1.4	1:1.6	1:1.8	1:2.1	1:2.5
No. 4 to ¾ in.	½ to 1	1:2.6:4.6	1:2.9:4.1	1:3.4:4.1	1:3.9:3.6	1:4.6:3.1
	3 " 4	1:2.3:4.0	1:2.6:3.8	1:2.9:3.6	1:3.4:3.2	1:4.1:2.8
	6 " 7	1:1.8:3.4	1:2.0:3.2	1:2.3:3.1	1:2.6:2.8	1:3.1:2.5
	8 " 10	1:1.1:2.5	1:1.3:2.4	1:1.5:2.4	1:1.7:2.2	1:2.1:2.0
No. 4 to 1 in.	½ to 1	1:2.4:5.3	1:2.7:5.2	1:3.1:5.0	1:3.5:4.7	1:4.3:4.1
	3 " 4	1:2.1:4.7	1:2.4:4.5	1:2.7:4.4	1:3.1:4.1	1:3.7:3.7
	6 " 7	1:1.6:3.9	1:1.8:3.8	1:2.1:3.7	1:2.4:3.5	1:2.9:3.3
	8 " 10	1:1.1:2.9	1:1.2:2.8	1:1.4:2.8	1:1.6:2.7	1:1.9:2.6
No. 4 to 1½ in.	½ to 1	1:2.4:6.0	1:2.7:5.9	1:3.1:5.8	1:3.5:5.4	1:4.1:5.1
	3 " 4	1:2.0:5.4	1:2.3:5.3	1:2.7:5.2	1:3.0:5.0	1:3.5:4.6
	6 " 7	1:1.6:4.4	1:1.8:4.3	1:2.0:4.3	1:2.3:4.1	1:2.7:3.9
	8 " 10	1:1.0:3.3	1:1.1:3.2	1:1.3:3.2	1:1.5:3.1	1:1.8:2.9
No. 4 to 2 in.	½ to 1	1:2.2:6.9	1:2.4:6.8	1:2.8:6.8	1:3.1:6.6	1:3.7:5.4
	3 " 4	1:1.8:6.2	1:2.0:6.1	1:2.4:6.1	1:2.7:6.0	1:3.1:5.7
	6 " 7	1:1.4:5.1	1:1.6:5.0	1:1.8:5.0	1:2.0:5.0	1:2.4:4.8
	8 " 10	1:0.9:3.8	1:1.0:3.8	1:1.1:3.8	1:1.3:3.8	1:1.5:3.7
⅜ to 1 in.	½ to 1	1:2.8:5.2	1:3.1:5.1	1:3.6:4.8	1:4.2:4.6	1:4.8:4.1
	3 " 4	1:2.4:4.5	1:2.6:4.5	1:3.1:4.3	1:3.6:4.0	1:4.1:3.6
	6 " 7	1:1.9:3.9	1:2.1:3.7	1:2.4:3.6	1:2.8:3.4	1:3.2:3.1
	8 " 10	1:1.3:2.8	1:1.4:2.8	1:1.6:2.7	1:1.9:2.6	1:2.2:2.4
⅜ to 1½ in.	½ to 1	1:2.8:5.8	1:3.1:5.7	1:3.5:5.5	1:4.1:5.3	1:4.7:4.9
	3 " 4	1:2.4:5.2	1:2.7:5.1	1:3.1:5.0	1:3.5:4.8	1:4.1:4.4
	6 " 7	1:1.9:4.3	1:2.1:4.2	1:2.4:4.2	1:2.7:4.0	1:3.1:3.7
	8 " 10	1:1.2:3.2	1:1.4:3.2	1:1.6:3.1	1:1.8:3.0	1:2.1:2.9
⅜ to 2 in.	½ to 1	1:2.7:6.6	1:3.0:6.6	1:3.4:6.5	1:3.9:6.4	1:4.4:6.0
	3 " 4	1:2.3:5.9	1:2.6:5.9	1:2.9:5.8	1:3.3:5.6	1:3.7:5.5
	6 " 7	1:1.8:4.9	1:2.0:4.8	1:2.2:4.8	1:2.6:4.8	1:3.0:4.5
	8 " 10	1:1.2:3.7	1:1.3:3.7	1:1.5:3.7	1:1.7:3.6	1:1.9:3.5
¾ to 1½ in.	½ to 1	1:3.2:5.4	1:3.6:5.3	1:4.1:5.1	1:4.7:4.8	1:5.3:4.4
	3 " 4	1:2.8:4.8	1:3.2:4.8	1:3.6:4.6	1:4.0:4.4	1:4.6:4.0
	6 " 7	1:2.1:4.0	1:2.5:4.0	1:2.8:3.9	1:3.2:3.7	1:3.5:3.4
	8 " 10	1:1.5:3.0	1:1.7:3.0	1:1.9:2.9	1:2.2:2.8	1:2.5:2.7
¾ to 2 in.	½ to 1	1:3.2:6.2	1:3.6:6.1	1:4.0:6.0	1:4.6:5.8	1:5.2:5.4
	3 " 4	1:2.8:5.5	1:3.1:5.5	1:3.5:5.4	1:3.9:5.2	1:4.5:4.9
	6 " 7	1:2.1:4.5	1:2.4:4.6	1:2.7:4.5	1:3.1:4.4	1:3.5:4.1
	8 " 10	1:1.4:3.4	1:1.6:3.4	1:1.8:3.4	1:2.1:3.4	1:2.4:3.3
¾ to 3 in.	½ to 1	1:3.2:7.1	1:3.6:7.1	1:4.0:7.0	1:4.6:6.9	1:5.2:6.6
	3 " 4	1:2.7:6.3	1:3.0:6.3	1:3.4:6.3	1:4.0:6.2	1:4.5:5.9
	6 " 7	1:2.1:5.1	1:2.4:5.2	1:2.7:5.2	1:3.1:5.1	1:3.5:4.9
	8 " 10	1:1.4:3.8	1:1.6:3.9	1:1.8:3.9	1:2.1:3.9	1:2.4:3.8

Quantities of Materials for 1 cu. yd. of 1,500 lb. per sq. in. Concrete.

[The volume of cement is expressed in barrels,* and of aggregates in cubic yards: F = fine aggregate; C = coarse aggregate. Quantities are net, no allowance being made for waste; for average conditions, the following additions are suggested: Cement, 2 per cent.; fine aggregate, 10 per cent.; coarse aggregate, 5 per cent.]

Size of Coarse Aggregate	Slump, in.	Quantities of Materials Using Fine Aggregate of Different Sizes											
		0-No. 30			0-No. 16			0-No. 8			0-No. 4			0-¾ in.		
		Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.
None	½ to 1	1.90	.79		1.77	.84		1.60	.90		1.36	.89		1.27	.96	
	3 " 4	2.12	.75		1.96	.81		1.75	.86		1.52	.86		1.38	.92	
	6 " 7	2.49	.70		2.33	.76		2.08	.80		1.81	.80		1.64	.88	
	8 " 10	2.98	.62		2.82	.67		2.36	.70		2.32	.72		2.10	.78	
No. 4 to ¾ in.	½ to 1	1.02	.39	.69	1.02	.44	.66	1.01	.51	.61	.98	.56	.52	.98	.57	45
	3 " 4	1.17	.40	.69	1.12	.43	.63	1.11	.48	.59	1.07	.54	.51	1.08	.65	.45
	6 " 7	1.39	.37	.70	1.36	.40	.64	1.31	.45	.60	1.30	.50	.54	1.27	.58	.47
	8 " 10	1.76	.29	.65	1.76	.34	.63	1.73	.38	.61	1.68	.42	.55	1.67	.52	.49
No. 4 to 1 in.	½ to 1	.98	.35	.77	.98	.39	.75	.96	.44	.71	.94	.49	.65	.93	.59	.59
	3 " 4	1.08	.34	.75	1.06	.38	.70	1.05	.42	.68	1.02	.47	.62	1.02	.56	.56
	6 " 7	1.32	.31	.76	1.30	.35	.73	1.23	.38	.67	1.21	.43	.63	1.21	.52	.59
	8 " 10	1.70	.28	.73	1.68	.30	.70	1.64	.34	.68	1.60	.38	.64	1.57	.44	.58
No. 4 to 1½ in.	½ to 1	.93	.33	.83	.93	.37	.81	.91	.42	.78	.88	.46	.70	.86	.52	.65
	3 " 4	1.02	.30	.81	1.03	.35	.81	1.01	.40	.78	.98	.43	.72	.97	.50	.66
	6 " 7	1.24	.29	.81	1.23	.33	.78	1.18	.35	.75	1.12	.38	.68	1.15	.46	.66
	8 " 10	1.62	.24	.79	1.59	.26	.75	1.54	.30	.73	1.50	.33	.69	1.50	.40	.64
No. 4 to 2 in.	½ to 1	.88	.29	.90	.88	.31	.88	.85	.35	86	82	.38	.80	.80	.44	.76
	3 " 4	.98	.26	.90	.99	.29	.89	.96	.34	.87	.93	.37	.82	.91	.42	.77
	6 " 7	1.17	.27	.88	1.16	.28	.86	1.13	.30	.84	1.09	.32	.81	1.09	.39	.78
	8 " 10	1.53	.20	.86	1.49	.22	.84	1.46	.24	.82	1.43	.27	.80	1.43	.32	.78
⅜ to 1 in.	½ to 1	1.00	.41	.77	.97	.44	.73	.95	.51	.68	.91	.56	.62	.92	.65	.56
	3 " 4	1.08	.38	.75	1.05	.40	.70	1.03	.47	.65	1.00	.53	.59	1.02	.62	.54
	6 " 7	1.32	.37	.76	1.27	.40	.70	1.25	.44	.67	1.20	.50	.60	1.21	.57	.56
	8 " 10	1.73	.33	.72	1.69	.35	.70	1.66	.39	.66	1.59	.45	.61	1.54	.50	.55
⅜ to 1½ in.	½ to 1	.93	.38	.80	.91	.42	.77	.90	.47	.73	.85	.52	.67	.85	.59	.62
	3 " 4	1.03	.37	.79	1.01	.40	.76	1.00	.46	.74	.95	.49	.68	.96	.58	.62
	6 " 7	1.22	.34	.78	1.21	.38	.75	1.18	.42	.73	1.17	.47	.69	1.13	.52	.62
	8 " 10	1.62	.29	.77	1.60	.33	.76	1.54	.36	.71	1.48	.39	.66	1.46	.45	.63
⅜ to 2 in.	½ to 1	.88	.35	.86	.86	.38	.84	.83	42	.80	.79	.45	.75	.77	.50	.68
	3 " 4	.98	.33	.85	.97	.37	.85	.95	.41	.81	.91	.44	.75	.90	.49	.73
	6 " 7	1.16	.31	.84	1.14	.34	.81	1.11	.36	.79	1.08	.42	.77	1.07	.48	.71
	8 " 10	1.51	.28	.87	1.50	.29	.82	1.45	.32	.79	1.40	.35	.75	1.38	.39	.71
¾ to 1½ in.	½ to 1	.91	.43	.73	.89	.47	.70	.87	.53	66	.82	.57	.58	.81	.63	.53
	3 " 4	1.00	.41	.71	1.00	.47	.71	.97	.52	.66	.93	.55	.60	.91	.62	.54
	6 " 7	1.20	.37	.71	1.20	.44	.71	1.15	.48	.66	1.11	.53	.61	1.08	.56	.54
	8 " 10	1.60	.36	.71	1.57	.39	.70	1.52	.43	.65	1.44	.47	.60	1.43	.53	.57
¾ to 2 in.	½ to 1	.85	.40	.78	.85	.45	.77	.80	.47	.71	.76	.52	.65	.74	.57	.59
	3 " 4	.96	.40	.78	.95	.44	.77	.92	.48	.73	.84	.48	.65	.86	.57	.62
	6 " 7	1.14	.35	.76	1.14	.41	.78	1.08	.43	.72	1.03	.47	.67	1.04	.54	.63
	8 " 10	1.50	.31	.75	1.46	.35	.73	1.43	.38	.72	1.37	.43	.69	1.34	.48	.65
¾ to 3 in.	½ to 1	.78	.37	.82	.76	.40	.80	.72	.43	.75	.67	.46	.68	65	.50	.63
	3 " 4	.91	.36	.85	.89	.40	.83	.86	.43	.80	.81	.48	.74	.79	.53	.69
	6 " 7	1.04	.32	.79	1.04	.37	.80	1.03	.41	.79	.98	.45	.88	.99	.51	.72
	8 " 10	1.43	.30	.80	1.39	.33	.80	1.35	.36	.78	1.30	.40	.75	1.25	.44	.70

* 1 barrel = 376 lb.

Proportions for 2,000 lb. per sq. in. Concrete.

[Based on 28-day compressive strength of 6 by 12 in. cylinders. Proportions are expressed by volume as follows: Portland cement: fine aggregate: coarse aggregate—Thus 1 : 2·6 : 4·6 indicates 1 part by volume of Portland cement, 2·6 parts by volume of fine aggregate, and 4·6 parts by volume of coarse aggregate.]

Size of Coarse Aggregate	Slump, in.	Proportions Using Fine Aggregate of Different Sizes				
		0-No. 30	0-No. 16	0-No. 8	0-No. 4	0-⅜ in.
None	½ to 1	1:2.2	1:2.6	1:3.0	1:3.5	1:4.1
	3 " 4	1:1.9	1:2.2	1:2.6	1:3.0	1:3.5
	6 " 7	1:1.5	1:1.7	1:2.0	1:2.3	1:2.7
	8 " 10	1:1.0	1:1.1	1:1.3	1:1.6	1:1.8
No. 4 to ¾ in.	½ to 1	1:2.1:3.8	1:2.3:3.7	1:2.6:3.5	1:3.0:3.1	1:3.6:2.8
	3 " 4	1:1.7:3.3	1:1.9:3.2	1:2.2:3.1	1:2.6:2.8	1:3.0:2.4
	6 " 7	1:1.3:2.7	1:1.4:2.6	1:1.7:2.5	1:1.9:2.3	1:2.3:2.1
	8 " 10	1:0.8:1.9	1:0.9:1.9	1:1.0:1.8	1:1.2:1.7	1:1.5:1.6
No. 4 to 1 in.	½ to 1	1:1.9:4.5	1:2.2:4.3	1:2.5:4.2	1:2.8:3.9	1:3.4:3.6
	3 " 4	1:1.6:3.9	1:1.8:3.8	1:2.1:3.7	1:2.4:3.5	1:2.8:3.2
	6 " 7	1:1.2:3.1	1:1.3:3.1	1:1.5:3.0	1:1.8:2.9	1:2.1:2.7
	8 " 10	1:0.7:2.2	1:0.8:2.2	1:1.0:2.3	1:1.1:2.1	1:1.3:2.0
No. 4 to 1½ in.	½ to 1	1:1.9:5.0	1:2.1:4.9	1:2.4:4.9	1:2.7:4.6	1:3.2:4.4
	3 " 4	1:1.6:4.4	1:1.7:4.3	1:2.0:4.2	1:2.4:4.0	1:2.7:3.8
	6 " 7	1:1.1:3.5	1:1.3:3.5	1:1.4:3.5	1:1.7:3.4	1:2.0:3.2
	8 " 10	1:0.7:2.5	1:0.8:2.5	1:0.9:2.5	1:1.0:2.4	1:1.2:2.3
No. 4 to 2 in.	½ to 1	1:1.7:5.8	1:1.9:5.7	1:2.1:5.8	1:2.4:5.6	1:2.8:5.5
	3 " 4	1:1.4:5.0	1:1.5:5.0	1:1.8:5.0	1:2.0:4.9	1:2.3:4.7
	6 " 7	1:1.0:4.1	1:1.1:4.1	1:1.2:4.1	1:1.4:4.1	1:1.7:3.9
	8 " 10	1:0.6:2.9	1:0.7:2.9	1:0.7:3.0	1:0.8:2.9	1:1.0:2.9
⅜ to 1 in.	½ to 1	1:2.2:4.4	1:2.5:4.2	1:2.8:4.1	1:3.3:3.8	1:3.8:3.4
	3 " 4	1:1.9:3.8	1:2.1:3.7	1:2.4:3.6	1:2.8:3.4	1:3.2:3.1
	6 " 7	1:1.4:3.1	1:1.5:3.0	1:1.8:3.0	1:2.1:2.8	1:2.4:2.5
	8 " 10	1:0.9:2.2	1:1.0:2.2	1:1.1:2.2	1:1.3:2.0	1:1.5:1.9
⅜ to 1½ in.	½ to 1	1:2.2:4.9	1:2.5:4.8	1:2.8:4.7	1:3.2:4.6	1:3.7:4.2
	3 " 4	1:1.9:4.3	1:2.1:4.2	1:2.4:4.1	1:2.7:4.0	1:3.1:3.7
	6 " 7	1:1.4:3.5	1:1.5:3.4	1:1.7:3.4	1:2.0:3.3	1:2.3:3.1
	8 " 10	1:0.9:2.5	1:1.0:2.5	1:1.1:2.4	1:1.3:2.4	1:1.5:2.3
⅜ to 2 in.	½ to 1	1:2.1:5.6	1:2.3:5.5	1:2.6:5.5	1:3.0:5.4	1:3.5:5.1
	3 " 4	1:1.7:4.8	1:2.0:4.8	1:2.2:4.8	1:2.5:4.7	1:2.9:4.4
	6 " 7	1:1.3:4.0	1:1.4:3.9	1:1.6:3.9	1:1.8:3.9	1:2.1:3.8
	8 " 10	1:0.8:2.9	1:0.9:2.9	1:1.0:2.9	1:1.2:2.9	1:1.3:2.8
¾ to 1½ in.	½ to 1	1:2.6:4.5	1:2.9:4.5	1:3.3:4.4	1:3.8:4.2	1:4.3:3.9
	3 " 4	1:2.2:3.9	1:2.5:3.9	1:2.8:3.8	1:3.2:3.6	1:3.6:3.3
	6 " 7	1:1.6:3.2	1:1.8:3.2	1:2.1:3.1	1:2.4:3.0	1:2.7:2.8
	8 " 10	1:1.0:2.3	1:1.2:2.3	1:1.4:2.2	1:1.6:2.2	1:1.8:2.1
¾ to 2 in.	½ to 1	1:2.5:5.2	1:2.8:5.2	1:3.2:5.1	1:3.6:5.0	1:4.1:4.7
	3 " 4	1:2.1:4.5	1:2.4:4.5	1:2.7:4.4	1:3.1:4.3	1:3.5:4.0
	6 " 7	1:1.6:3.7	1:1.8:3.7	1:2.0:3.7	1:2.3:3.6	1:2.6:3.5
	8 " 10	1:1.0:2.6	1:1.1:2.7	1:1.3:2.6	1:1.5:2.7	1:1.7:2.6
¾ to 3 in.	½ to 1	1:2.5:6.0	1:2.9:5.9	1:3.2:5.9	1:3.6:5.8	1:4.1:5.6
	3 " 4	1:2.1:5.1	1:2.4:5.2	1:2.7:5.2	1:3.1:5.1	1:3.5:4.9
	6 " 7	1:1.5:4.1	1:1.7:4.2	1:2.0:4.2	1:2.3:4.2	1:2.5:4.0
	8 " 10	1:1.0:2.9	1:1.1:3.0	1:1.3:3.0	1:1.5:3.0	1:1.7:3.0

Quantities of Materials for 1 cu. yd. of 2,000 lb. per sq. in. Concrete.

[The volume of cement is expressed in barrels,* and of aggregates in cubic yards: F = fine aggregate; C = coarse aggregate. Quantities are net, no allowance being made for waste; for average conditions, the following additions are suggested: Cement, 2 per cent.; fine aggregate, 10 per cent.; coarse aggregate, 5 per cent.]

Size of Coarse Aggregate	Slump, in.	Quantities of Materials Using Fine Aggregate of Different Sizes											
		0-No. 30			0-No. 16			0-No. 8			0-No. 4			0-¾ in.		
		Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.
None.....	½ to 1	2.31	.75		2.12	.82		1.92	.85		1.65	.85		1.42	.86	
	3 " 4	2.55	.72		2.39	.78		2.12	.82		1.85	.82		1.71	.89	
	6 " 7	2.94	.65		2.83	.71		2.52	.75		2.24	.76		2.06	.83	
	8 " 10	3.60	.53		3.54	.58		3.25	.62		2.80	.66		2.62	.70	
No. 4 to ¾ in..	½ to 1	1.27	.40	.71	1.24	.42	.68	1.19	.46	.62	1.17	.52	.54	1.17	.62	.48
	3 " 4	1.43	.36	.70	1.40	.39	.66	1.36	.44	.62	1.34	.51	.56	1.32	.59	.47
	6 " 7	1.71	.33	.68	1.70	.35	.66	1.66	.42	.61	1.60	.45	.54	1.59	.54	.50
	8 " 10	2.25	.27	.63	2.23	.30	.63	2.20	.33	.59	2.13	.38	.54	2.10	.47	.50
No. 4 to 1 in...	½ to 1	1.19	.33	.79	1.17	.38	.74	1.13	.42	.70	1.10	.46	.64	1.09	.55	.58
	3 " 4	1.36	.32	.78	1.32	.35	.74	1.26	.39	.69	1.24	.44	.64	1.24	.51	.59
	6 " 7	1.65	.29	.76	1.62	.31	.74	1.56	.35	.69	1.52	.40	.65	1.51	.47	.60
	8 " 10	2.15	.22	.70	2.13	.25	.69	2.07	.31	.70	2.01	.33	.63	1.98	.38	.59
No. 4 to 1½ in.	½ to 1	1.10	.31	.81	1.09	.34	.79	1.07	.38	.78	1.05	.42	.71	1.04	.49	.68
	3 " 4	1.26	.30	.82	1.25	.31	.79	1.20	.35	.74	1.17	.42	.69	1.16	.46	.65
	6 " 7	1.54	.25	.80	1.52	.29	.79	1.47	.30	.76	1.44	.36	.72	1.43	.42	.68
	8 " 10	2.04	.21	.75	2.00	.24	.74	1.94	.26	.72	1.88	.28	.67	1.88	.33	.64
No. 4 to 2 in...	½ to 1	1.04	.26	.89	1.05	.29	.88	1.04	.32	.89	1.00	.35	.83	.98	.41	.80
	3 " 4	1.20	.25	.89	1.19	.26	.88	1.16	.31	.86	1.11	.33	.80	1.12	.38	.78
	6 " 7	1.47	.22	.89	1.45	.24	.88	1.38	.25	.84	1.35	.28	.82	1.36	.34	.79
	8 " 10	1.92	.17	.82	1.89	.20	.81	1.85	.19	.82	1.81	.21	.78	1.80	.27	.77
⅜ to 1 in.....	½ to 1	1.17	.38	.76	1.16	.43	.72	1.12	.46	.68	1.10	.54	.62	1.10	.62	.55
	3 " 4	1.34	.38	.75	1.33	.41	.73	1.29	.46	.69	1.23	.51	.62	1.23	.58	.56
	6 " 7	1.67	.35	.77	1.63	.36	.72	1.57	.42	.70	1.51	.47	.63	1.53	.54	.57
	8 " 10	2.16	29	.70	2.12	.31	.69	2.06	.34	.67	2.01	.39	.60	1.93	.43	.54
⅜ to 1½ in....	½ to 1	1.10	.36	.80	1.07	.40	.76	1.05	.43	.73	1.02	.48	.69	1.03	.56	.64
	3 " 4	1.25	.35	.79	1.24	.39	.77	1.21	.43	.73	1.16	.46	.69	1.15	.53	.63
	6 " 7	1.54	.32	.80	1.52	.34	.77	1.47	.37	.74	1.42	.42	.69	1.41	.48	.65
	8 " 10	2.05	.27	.76	2.00	.29	.74	1.93	.31	.70	1.89	.36	.67	1.83	.41	.62
⅜ to 2 in.....	½ to 1	1.05	.33	.85	1.03	.35	.84	1.01	.39	.82	.98	.43	.78	.97	.50	.73
	3 " 4	1.19	.30	.85	1.18	.35	.84	1.14	.37	.81	1.10	.41	.76	1.09	.47	.71
	6 " 7	1.46	.28	.86	1.45	.30	.84	1.40	.33	.81	1.33	.35	.77	1.31	.41	.74
	8 " 10	1.91	23	.82	1.88	.25	.81	1.83	.27	.79	1.80	.32	.77	1.74	.34	.72
¾ to 1½ in....	½ to 1	1.07	.41	.71	1.06	.45	.71	1.02	.50	.66	.98	.55	.61	.98	.62	.57
	3 " 4	1.23	.40	.71	1.23	.45	.71	1.19	.49	.67	1.12	.53	.60	1.10	.59	.54
	6 " 7	1.51	.36	.72	1.49	.40	.71	1.45	.45	.67	1.36	.48	.60	1.36	.54	.56
	8 " 10	2.01	.30	.69	1.97	.35	.67	1.91	.40	.62	1.81	.43	.59	1.79	.48	.56
¾ to 2 in.....	½ to 1	1.02	.38	.79	1.02	.42	.78	.99	.47	.75	.94	.50	.70	.93	.56	.65
	3 " 4	1.17	.36	.78	1.16	.41	.77	1.11	.44	.72	1.05	.48	.67	1.04	.54	.61
	6 " 7	1.44	.34	.79	1.41	.38	.77	1.37	.41	.75	1.31	.45	.70	1.26	.48	.65
	8 " 10	1.88	.28	.72	1.85	.30	.74	1.82	.35	.70	1.74	.39	.69	1.70	.43	.65
¾ to 3 in.....	½ to 1	.96	.36	.85	.95	.41	.83	.92	.44	.80	.88	.47	.75	.86	.52	.71
	3 " 4	1.08	.34	.81	1.08	.38	.83	1.05	.42	.81	1.00	.46	.76	.98	.51	.71
	6 " 7	1.36	.30	.83	1.30	.33	.81	1.25	.38	.80	1.23	.42	.77	1.20	.44	.71
	8 " 10	1.81	.27	.78	1.76	.29	.78	1.72	33	.76	1.65	.37	73	1.60	.40	71

* 1 barrel = 376 lb.

Proportions for 2,500 lb. per sq. in. Concrete.

[Based on 28-day compressive strength of 6 by 12 in. cylinders. Proportions are expressed by volume as follows: Portland cement: fine aggregate: coarse aggregate—Thus 1 : 2·6 : 4·6 indicates 1 part of Portland cement, 2·6 parts by volume of fine aggregate, and 4·6 parts by volume of coarse aggregate.]

Size of Coarse Aggregate	Slump, in.	Proportions Using Fine Aggregate of Different Sizes				
		0-No. 30	0-No. 16	0-No. 8	0-No. 4	0-⅜ in.
None	½ to 1	1:1.8	1:2.1	1:2.4	1:2.9	1:3.3
	3 " 4	1:1.5	1:1.8	1:2.1	1:2.4	1:2.8
	6 " 7	1:1.1	1:1.3	1:1.6	1:1.8	1:2.1
	8 " 10	1:0.7	1:0.8	1:0.9	1:1.1	1:1.3
No. 4 to ¾ in.	½ to 1	1:1.6:3.2	1:1.8:3.1	1:2.1:3.0	1:2.4:2.7	1:2.9:2.4
	3 " 4	1:1.3:2.8	1:1.5:2.7	1:1.7:2.6	1:2.0:2.4	1:2.4:2.2
	6 " 7	1:1.0:2.2	1:1.1:2.2	1:1.3:2.1	1:1.5:2.0	1:1.8:1.8
	8 " 10	1:0.5:1.4	1:0.6:1.4	1:0.7:1.4	1:0.8:1.4	1:1.0:1.3
No. 4 to 1 in.	½ to 1	1:1.5:3.7	1:1.7:3.7	1:2.0:3.5	1:2.2:3.4	1:2.7:3.1
	3 " 4	1:1.2:3.3	1:1.4:3.2	1:1.6:3.1	1:1.9:3.0	1:2.2:2.7
	6 " 7	1:0.9:2.6	1:1.0:2.5	1:1.1:2.5	1:1.3:2.4	1:1.6:2.3
	8 " 10	1:0.5:1.7	1:0.6:1.7	1:0.6:1.7	1:0.7:1.6	1:0.9:1.5
No. 4 to 1½ in.	½ to 1	1:1.4:4.2	1:1.6:4.1	1:1.9:4.1	1:2.2:4.0	1:2.5:3.8
	3 " 4	1:1.2:3.7	1:1.3:3.6	1:1.5:3.6	1:1.8:3.5	1:2.1:3.3
	6 " 7	1:0.9:2.9	1:0.9:2.8	1:1.1:2.8	1:1.3:2.8	1:1.5:2.6
	8 " 10	1:0.5:1.9	1:0.5:1.9	1:0.6:1.9	1:0.7:1.8	1:0.8:1.8
No. 4 to 2 in.	½ to 1	1:1.3:4.9	1:1.4:4.8	1:1.6:4.9	1:1.9:4.8	1:2.2:4.7
	3 " 4	1:1.1:4.3	1:1.2:4.2	1:1.3:4.3	1:1.6:4.2	1:1.8:4.1
	6 " 7	1:0.7:3.3	1:0.8:3.3	1:0.9:3.4	1:1.1:3.3	1:1.2:3.3
	8 " 10	1:0.4:2.2	1:0.4:2.2	1:0.5:2.2	1:0.6:2.2	1:0.6:2.2
⅜ to 1 in.	½ to 1	1:1.8:3.7	1:2.0:3.6	1:2.3:3.5	1:2.6:3.3	1:3.0:2.9
	3 " 4	1:1.4:3.2	1:1.6:3.1	1:1.9:2.9	1:2.2:2.9	1:2.5:2.6
	6 " 7	1:1.0:2.5	1:1.2:2.5	1:1.3:2.4	1:1.6:2.3	1:1.8:2.2
	8 " 10	1:0.6:1.6	1:0.7:1.6	1:0.8:1.6	1:0.9:1.6	1:1.0:1.5
⅜ to 1½ in.	½ to 1	1:1.7:4.1	1:1.9:4.1	1:2.2:4.0	1:2.5:3.9	1:2.9:3.6
	3 " 4	1:1.5:3.6	1:1.6:3.6	1:1.8:3.5	1:2.1:3.4	1:2.3:3.2
	6 " 7	1:1.0:2.9	1:1.2:2.8	1:1.3:2.8	1:1.5:2.7	1:1.8:2.6
	8 " 10	1:0.6:1.9	1:0.6:1.9	1:0.8:1.8	1:0.9:1.8	1:1.0:1.8
⅜ to 2 in.	½ to 1	1:1.7:4.7	1:1.8:4.7	1:2.1:4.7	1:2.4:4.6	1:2.7:4.4
	3 " 4	1:1.4:4.1	1:1.5:4.1	1:1.7:4.1	1:2.0:4.0	1:2.3:3.9
	6 " 7	1:1.0:3.2	1:1.1:3.2	1:1.2:3.2	1:1.4:3.2	1:1.6:3.1
	8 " 10	1:0.5:2.1	1:0.6:2.1	1:0.7:2.2	1:0.8:2.2	1:0.9:2.1
¾ to 1½ in.	½ to 1	1:2.0:3.8	1:2.3:3.8	1:2.6:3.7	1:3.0:3.6	1:3.4:3.3
	3 " 4	1:1.7:3.3	1:2.0:3.3	1:2.2:3.2	1:2.5:3.2	1:2.9:2.9
	6 " 7	1:1.2:2.6	1:1.4:2.6	1:1.6:2.6	1:1.9:2.5	1:2.1:2.3
	8 " 10	1:0.7:1.7	1:0.8:1.7	1:0.9:1.7	1:1.1:1.7	1:1.2:1.6
¾ to 2 in.	½ to 1	1:2.0:4.4	1:2.2:4.4	1:2.5:4.3	1:2.9:4.3	1:3.3:4.1
	3 " 4	1:1.7:3.8	1:1.9:3.8	1:2.1:3.8	1:2.5:3.7	1:2.8:3.6
	6 " 7	1:1.2:3.0	1:1.4:3.0	1:1.5:3.0	1:1.8:3.0	1:2.0:2.8
	8 " 10	1:0.7:2.0	1:0.8:2.0	1:0.9:2.0	1:1.0:2.0	1:1.2:2.0
¾ to 3 in.	½ to 1	1:2.0:5.0	1:2.2:5.0	1:2.5:5.0	1:2.7:5.0	1:3.2:4.7
	3 " 4	1:1.7:4.3	1:1.9:4.3	1:2.1:4.3	1:2.4:4.3	1:2.7:4.1
	6 " 7	1:1.2:3.3	1:1.4:3.4	1:1.5:3.4	1:1.8:3.4	1:2.0:3.3
	8 " 10	1:0.7:2.2	1:0.8:2.2	1:0.9:2.2	1:1.0:2.3	1:1.2:2.3

Quantities of Materials for 1 cu. yd. of 2,500 lb. per sq. in. Concrete.

[The volume of cement is expressed in barrels,* and of aggregates in cubic yards: F = fine aggregate; C = coarse aggregate. Quantities are net, no allowance being made for waste; for average conditions, the following additions are suggested: Cement, 2 per cent.; fine aggregate, 10 per cent.; coarse aggregate, 5 per cent.]

Size of Coarse Aggregate	Slump, in.	Quantities of Materials Using Fine Aggregate of Different Sizes									
		0-No. 30		0-No. 16		0-No. 8		0-No. 4		0-¾ in.	
		Cement	Aggregate F. C.	Cement	Aggregate F. C.	Cement	Aggregate F. C.	Cement	Aggregate F. C.	Cement	Aggregate F. C.
None	½ to 1	2.71	.72	2.53	.79	2.30	.82	1.94	.83	1.83	.89
	3 " 4	3.01	.67	2.78	.74	2.50	.78	2.20	.78	2.05	.85
	6 " 7	3.60	.59	3.38	.65	2.97	.70	2.71	.72	2.45	.76
	8 " 10	4 24	.44	4.11	.49	3.91	.52	3.46	.56	3.16	.61
No. 4 to ¾ in.	½ to 1	1 49	.35 .70	1.46	.39 .67	1.42	.44 .63	1.39	.49 .55	1.39	.60 .49
	3 " 4	1 68	.32 .70	1.67	.37 .67	1.63	.41 .63	1.57	.46 .56	1.54	.55 .50
	6 " 7	2.06	.30 .67	2.03	.33 .66	1.98	.38 .62	1.89	.42 .56	1.89	.50 .50
	8 " 10	2 83	.21 .59	2.78	.25 .58	2.71	.28 .56	2.64	.31 .55	2.58	.38 .50
No. 4 to 1 in.	½ to 1	1.42	.32 .78	1.39	.35 .76	1.35	.40 .70	1.30	.42 .65	1.29	.51 .59
	3 " 4	1.61	.29 .79	1.56	.32 .74	1.51	.36 .69	1.48	.41 .65	1.47	.48 .59
	6 " 7	1.95	.26 .75	1.90	.28 .70	1.87	.30 .69	1.82	.35 .65	1.81	.43 .62
	8 " 10	2.68	.19 .65	2.64	.23 .66	2.54	.23 .64	2.50	.26 .59	2.58	.33 .55
No. 4 to 1½ in.	½ to 1	1.34	.27 .83	1.32	.31 .80	1.25	.35 .76	1.23	.40 .73	1.23	.45 .69
	3 " 4	1.50	.27 .82	1.48	.28 .79	1.43	.32 .76	1.39	.37 .72	1.39	.43 .68
	6 " 7	1.83	.24 .79	1.83	.24 .76	1.78	.29 .74	1.73	.33 .72	1.72	.38 .66
	8 " 10	2.50	.19 .70	2.49	.18 .70	2.42	.21 .68	2.40	.25 .64	2.39	.28 .64
No. 4 to 2 in.	½ to 1	1.25	.24 .91	1.24	.26 .88	1.21	.29 .88	1.17	.33 .83	1.13	.37 .79
	3 " 4	1.44	.23 .92	1.41	.25 .88	1.36	.26 .87	1.31	.31 .81	1.32	.35 .80
	6 " 7	1.77	.18 .87	1.75	.21 .86	1.70	.23 .86	1.65	.27 .81	1.63	.29 .80
	8 " 10	2.43	.14 .79	2.42	.14 .79	2.38	.18 .78	2.32	.21 .75	2.31	.20 .75
⅜ to 1 in.	½ to 1	1.41	.38 .77	1.39	.41 .74	1.34	.46 .69	1.29	.50 .63	1.29	.57 .55
	3 " 4	1.61	.33 .76	1.57	.37 .72	1.51	.42 .65	1.47	.48 .63	1.45	.54 .56
	6 " 7	1.97	.29 .73	1.91	.34 .71	1.87	.36 .66	1.83	.43 .62	1.78	.47 .58
	8 " 10	2.64	.23 .62	2.62	.27 .62	2.56	.30 .61	2.47	.33 .58	2.42	.36 .54
⅜ to 1½ in.	½ to 1	1.32	.33 .80	1.30	.37 .79	1.27	.41 .75	1.22	.45 .70	1.21	.52 .64
	3 " 4	1.49	.33 .79	1.48	.35 .79	1.43	.38 .74	1.38	.43 .69	1.37	.47 .65
	6 " 7	1.86	.28 .80	1.83	.33 .76	1.77	.34 .74	1.73	.38 .69	1.68	.45 .65
	8 " 10	2.49	.22 .70	2.46	.22 .69	2.41	.29 .64	2.38	.32 .63	2.32	.34 .62
⅜ to 2 in.	½ to 1	1.24	.31 .86	1.23	.33 .85	1.09	.34 .76	1.15	.41 .78	1.12	.45 .73
	3 " 4	1.41	.29 .85	1.40	.31 .85	1.35	.34 .82	1.29	.38 .76	1.28	.44 .74
	6 " 7	1.77	.26 .84	1.74	.28 .82	1.68	.30 .80	1.62	.34 .77	1.58	.38 .73
	8 " 10	2.41	.18 .75	2.37	.21 .74	2.32	.24 .76	2.30	.27 .75	2.22	.30 .69
¾ to 1½ in.	½ to 1	1.30	.38 .73	1.29	.44 .72	1.21	.47 .66	1.18	.52 .63	1.16	.58 .57
	3 " 4	1.47	.37 .72	1.45	.43 .71	1.40	.46 .66	1.35	.50 .64	1.32	.57 .57
	6 " 7	1.80	.32 .69	1.80	.37 .69	1.75	.42 .67	1.67	.47 .62	1.64	.51 .56
	8 " 10	2.48	.26 .63	2.45	.29 .62	2.40	.32 .60	2.31	.38 .58	2.27	.40 .54
¾ to 2 in.	½ to 1	1.22	.36 .79	1.22	.40 .79	1.18	.44 .75	1.10	.47 .70	1.07	.52 .65
	3 " 4	1.41	.35 .79	1.38	.39 .77	1.33	.41 .75	1.27	.47 .69	1.23	.51 .65
	6 " 7	1.74	.31 .77	1.70	.35 .76	1.66	.37 .74	1.58	.42 .70	1.53	.45 .64
	8 " 10	2.40	.25 .71	2.36	.28 .70	2.29	.31 .68	2.22	.33 .60	2.17	.38 .64
¾ to 3 in.	½ to 1	1.15	.34 .85	1.13	.37 .84	1.10	.41 .81	1.05	.42 .78	1.02	.48 .71
	3 " 4	1.33	.33 .84	1.30	.37 .83	1.25	.39 .79	1.21	.43 .77	1.18	.47 .72
	6 " 7	1.67	.30 .82	1.59	.33 .80	1.55	.34 .78	1.49	.40 .75	1.45	.43 .71
	8 " 10	2.32	.24 .75	2.27	.27 .74	2.20	.29 .72	2.13	.32 .73	2.12	.38 .72

* 1 barrel = 376 lb.

Proportions for 3,000 lb. per sq. in. Concrete.

[Based on 28-day compressive strength of 6 by 12 in. cylinders. Proportions are expressed by volume as follows: Portland cement: fine aggregate: coarse aggregate—Thus 1 : 2·6 : 4·6 indicates 1 part by volume of Portland cement, 2·6 parts by volume of fine aggregate, and 4·6 parts by volume of coarse aggregate.]

Size of Coarse Aggregate	Slump, in.	Proportions Using Fine Aggregate of Different Sizes				
		0-No. 30	0-No. 16	0-No. 8	0-No. 4	0-⅜ in.
None	½ to 1	1:1.5	1:1.7	1:2.0	1:2.3	1:2.7
	3 " 4	1:1.2	1:1.4	1:1.7	1:1.9	1:2.3
	6 " 7	**1:0.9**	**1:1.0**	**1:1.2**	**1:1.4**	**1:1.6**
	8 " 10	1:0.6	1:0.6	1:0.7	1:0.8	1:0.9
No. 4 to ¾ in.	½ to 1	1:1.3:2.7	1:1.5:2.6	1:1.7:2.5	1:1.9:2.4	1:2.3:2.1
	3 " 4	1:1.0:2.3	1:1.2:2.2	1:1.4:2.2	1:1.6:2.0	1:1.9:1.8
	6 " 7	**1:0.7:1.7**	**1:0.8:1.7**	**1:0.9:1.7**	**1:1.1:1.6**	**1:1.3:1.4**
	8 " 10	1:0.3:1.0	1:0.4:1.0	1:0.5:1.0	1:0.5:1.0	1:0.6:0.9
No. 4 to 1 in.	½ to 1	1:1.2:3.1	1:1.3:3.1	1:1.5:3.0	1:1.8:2.9	1:2.1:2.7
	3 " 4	1:0.9:2.7	1:1.1:2.6	1:1.2:2.6	1:1.4:2.5	1:1.7:2.3
	6 " 7	**1:0.6:2.0**	**1:0.7:2.0**	**1:0.8:2.0**	**1:0.9:1.9**	**1:1.1:1.8**
	8 " 10	1:0.3:1.2	1:0.3:1.2	1:0.4:1.2	1:0.5:1.2	1:0.6:1.2
No. 4 to 1½ in.	½ to 1	1:1.1:3.6	1:1.2:3.5	1:1.5:3.5	1:1.7:3.4	1:2.0:3.2
	3 " 4	1:0.9:3.0	1:1.0:2.9	1:1.2:2.9	1:1.4:2.9	1:1.6:2.7
	6 " 7	**1:0.6:2.2**	**1:0.7:2.2**	**1:0.8:2.2**	**1:0.9:2.2**	**1:1.1:2.1**
	8 " 10	1:0.3:1.4	1:0.3:1.3	1:0.4:1.4	1:0.5:1.4	1:0.5:1.3
No. 4 to 2 in.	½ to 1	1:1.0:4.1	1:1.1:4.1	1:1.2:4.1	1:1.4:4.1	1:1.6:4.0
	3 " 4	1:0.8:3.4	1:0.9:3.4	1:1.0:3.5	1:1.1:3.4	1:1.3:3.4
	6 " 7	**1:0.5:2.6**	**1:0.6:2.6**	**1:0.6:2.7**	**1:0.7:2.6**	**1:0.9:2.6**
	8 " 10	1:0.2:1.6	1:0.3:1.6	1:0.3:1.7	1:0.4:1.7	1:0.4:1.7
⅜ to 1 in.	½ to 1	1:1.4:3.1	1:1.5:3.0	1:1.8:2.9	1:2.1:2.8	1:2.4:2.6
	3 " 4	1:1.1:2.6	1:1.3:2.6	1:1.5:2.5	1:1.7:2.4	1:2.0:2.2
	6 " 7	**1:0.8:2.0**	**1:0.8:2.0**	**1:1.0:1.9**	**1:1.1:1.9**	**1:1.3:1.8**
	8 " 10	1:0.4:1.2	1:0.4:1.2	1:0.5:1.2	1:0.6:1.2	1:0.7:1.1
⅜ to 1½ in.	½ to 1	1:1.4:3.5	1:1.5:3.4	1:1.7:3.4	1:2.0:3.3	1:2.3:3.1
	3 " 4	1:1.1:3.0	1:1.2:2.9	1:1.4:2.9	1:1.6:2.8	1:1.9:2.6
	6 " 7	**1:0.8:2.2**	**1:0.8:2.2**	**1:1.0:2.2**	**1:1.1:2.1**	**1:1.3:2.0**
	8 " 10	1:0.4:1.4	1:0.4:1.4	1:0.5:1.4	1:0.6:1.3	1:0.7:1.3
⅜ to 2 in.	½ to 1	1:1.3:4.0	1:1.4:4.0	1:1.6:4.0	1:1.9:3.9	1:2.1:3.8
	3 " 4	1:1.0:3.4	1:1.2:3.4	1:1.3:3.3	1:1.5:3.3	1:1.7:3.2
	6 " 7	**1:0.7:2.6**	**1:0.8:2.5**	**1:0.9:2.6**	**1:1.0:2.6**	**1:1.1:2.5**
	8 " 10	1:0.4:1.6	1:0.4:1.6	1:0.5:1.6	1:0.5:1.6	1:0.6:1.6
¾ to 1½ in.	½ to 1	1:1.6:3.2	1:1.8:3.2	1:2.1:3.2	1:2.4:3.1	1:2.7:2.9
	3 " 4	1:1.3:2.7	1:1.5:2.7	1:1.7:2.7	1:2.0:2.6	1:2.3:2.5
	6 " 7	**1:0.9:2.0**	**1:1.0:2.1**	**1:1.2:2.0**	**1:1.4:2.0**	**1:1.5:1.8**
	8 " 10	1:0.5:1.2	1:0.6:1.3	1:0.6:1.3	1:0.7:1.3	1:0.8:1.2
¾ to 2 in.	½ to 1	1:1.6:3.7	1:1.8:3.7	1:2.0:3.7	1:2.4:3.6	1:2.6:3.5
	3 " 4	1:1.3:3.1	1:1.5:3.1	1:1.6:3.1	1:1.9:3.1	1:2.2:3.0
	6 " 7	**1:0.9:2.4**	**1:1.1:2.4**	**1:1.1:2.4**	**1:1.3:2.4**	**1:1.5:2.3**
	8 " 10	1:0.5:1.5	1:0.6:1.5	1:0.6:1.5	1:0.7:1.5	1:0.8:1.5
¾ to 3 in.	½ to 1	1:1.6:4.2	1:1.8:4.2	1:2.0:4.2	1:2.3:4.1	1:2.6:4.0
	3 " 4	1:1.3:3.5	1:1.5:3.6	1:1.6:3.6	1:1.9:3.6	1:2.1:3.5
	6 " 7	**1:0.9:2.6**	**1:1.0:2.6**	**1:1.1:2.6**	**1:1.3:2.6**	**1:1.4:2.6**
	8 " 10	1:0.5:1.6	1:0.5:1.6	1:0.6:1.7	1:0.7:1.7	1:0.8:1.7

Quantities of Materials for 1 cu. yd. of 3,000 lb. per sq. in. Concrete.

[The volume of cement is expressed in barrels,* and of aggregates in cubic yards: F = fine aggregate; C = coarse aggregate. Quantities are net, no allowance being made for waste; for average conditions, the following additions are suggested: Cement, 2 per cent.; fine aggregate, 10 per cent.; coarse aggregate, 5 per cent.]

Size of Coarse Aggregate	Slump, in.	Quantities of Materials Using Fine Aggregate of Different Sizes											
		0-No. 30			0-No. 16			0-No. 8			0-No. 4			0-¾ in.		
		Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.
None	½ to 1	3.08	.68		2.96	.74		2.65	.78		2.34	.80		2.14	.86	
	3 " 4	3.61	.64		3.31	.69		2.93	.74		2.66	.75		2.37	.81	
	6 " 7	**3.99**	**.53**		**3.79**	**.56**		**3.57**	**.63**		**3.18**	**.66**		**2.93**	**.69**	
	8 " 10	4.77	.35		4.63	.41		4.34	.45		3.93	.47		3.79	.50	
No. 4 to ¾ in.	½ to 1	1.75	.34	.70	1.73	.38	.66	1.69	.42	.63	1.63	.46	.58	1.59	.54	.49
	3 " 4	2.00	.30	.68	1.97	.35	.64	1.93	.40	.63	1.86	.44	.55	1.86	.52	.49
	6 " 7	**2.48**	**.26**	**.62**	**2.46**	**.29**	**.62**	**2.38**	**.32**	**.60**	**2.37**	**.39**	**.56**	**2.35**	**.45**	**.49**
	8 " 10	3.46	.15	.51	3.44	.20	.51	3.38	.25	.50	3.34	.25	.49	3.31	.29	.44
No. 4 to 1 in.	½ to 1	1.68	.30	.77	1.65	.32	.76	1.60	.36	.71	1.55	.41	.66	1.53	.47	.61
	3 " 4	1.88	.25	.75	1.86	.30	.72	1.83	.32	.70	1.78	.37	.66	1.76	.44	.60
	6 " 7	**2.39**	**.21**	**.71**	**2.38**	**.25**	**.70**	**2.32**	**.27**	**.69**	**2.27**	**30**	**.64**	**2.26**	**.37**	**.60**
	8 " 10	3.32	.15	.59	3.30	.15	.59	3.25	.19	.58	3.21	24	.57	3.18	.28	.56
No. 4 to 1½ in.	½ to 1	1.58	.23	.84	1.55	.28	.80	1.50	.33	.78	1.46	.37	.73	1.46	.43	.69
	3 " 4	1.80	.24	.80	1.78	.26	.76	1.73	.31	.74	1.68	.35	.72	1.67	.40	.67
	6 " 7	**2.30**	**.20**	**.75**	**2.27**	**.24**	**.74**	**2.21**	**.26**	**.72**	**2.15**	**.29**	**.70**	**2.12**	**.35**	**.66**
	8 " 10	3.19	.14	.66	3.17	.14	.61	3.09	.18	.64	3.04	.22	.63	3.02	.22	.58
No. 4 to 2 in.	½ to 1	1.50	.22	.91	1.49	.24	.90	1.43	.25	.87	1.38	.29	.84	1.38	.33	.82
	3 " 4	1.73	.20	.87	1.71	.23	.86	1.65	.24	.85	1.60	.26	.81	1.60	.31	.80
	6 " 7	**2.18**	**.16**	**.84**	**2.14**	**.19**	**.82**	**2.06**	**.18**	**.82**	**2.01**	**.21**	**.77**	**2.01**	**.27**	**.77**
	8 " 10	3.12	.09	.74	3.09	.14	.73	3.04	.14	.76	2.94	.17	.74	2.94	.17	.74
⅜ to 1 in.	½ to 1	1.69	.35	.77	1.65	.37	.73	1.60	.43	.69	1.54	.48	.64	1.51	.54	.58
	3 " 4	1.91	.31	.73	1.88	.36	.72	1.82	.40	.67	1.78	.45	.63	1.73	.51	.56
	6 " 7	**2.40**	**.28**	**.71**	**2.36**	**.28**	**.70**	**2.31**	**.34**	**.65**	**2.26**	**.37**	**.64**	**2.19**	**.42**	**.58**
	8 " 10	3.23	.19	.57	3.21	.19	.57	3.15	.23	.56	3.00	.27	.53	2.93	.30	.48
⅜ to 1½ in.	½ to 1	1.57	.32	.81	1.55	.34	.78	1.50	.38	.75	1.45	.43	.71	1.43	.49	.66
	3 " 4	1.81	.30	.81	1.78	.32	.76	1.73	.36	.74	1.68	.40	.70	1.63	.46	.63
	6 " 7	**2.30**	**.20**	**.75**	**2.26**	**.27**	**.74**	**2.20**	**.33**	**.72**	**2.15**	**.35**	**.67**	**2.08**	**.35**	**.62**
	8 " 10	2.97	.18	.61	2.94	.17	.61	2.88	.21	.60	2.87	.26	.60	2.78	.30	.55
⅜ to 2 in.	½ to 1	1.49	.29	.88	1.48	.32	.88	1.42	.34	.84	1.36	.38	.77	1.34	.42	.75
	3 " 4	1.73	.26	.87	1.70	.30	.86	1.63	.31	.80	1.58	.35	.77	1.55	.39	.73
	6 " 7	**2.18**	**.23**	**.84**	**2.12**	**.25**	**.79**	**2.05**	**.27**	**.79**	**2.01**	**.30**	**.77**	**1.93**	**.31**	**.72**
	8 " 10	2.98	.18	.71	2.99	.18	.71	2.90	.21	.69	2.93	.22	.69	2.84	.25	.67
¾ to 1½ in.	½ to 1	1.55	.37	.73	1.52	.40	.72	1.48	.46	.70	1.41	.50	.65	1.38	.55	.59
	3 " 4	1.79	.34	.71	1.75	.39	.70	1.71	.43	.68	1.63	.48	.63	1.59	.54	.59
	6 " 7	**2.29**	**.30**	**.68**	**2.24**	**.33**	**.70**	**2.17**	**.39**	**.64**	**2.08**	**.43**	**.62**	**2.03**	**.45**	**.54**
	8 " 10	3.03	.22	.54	3.01	.22	.58	2.93	.26	.56	2.90	.30	.56	2.88	.34	.51
¾ to 2 in.	½ to 1	1.47	.35	.80	1.44	.38	.79	1.40	.41	.77	1.34	.48	.71	1.29	.50	.67
	3 " 4	1.70	.33	.78	1.66	.37	.76	1.62	.38	.74	1.53	.43	.70	1.50	.49	.67
	6 " 7	**2.16**	**.29**	**.77**	**2.08**	**.34**	**.74**	**2.04**	**.33**	**.73**	**1.92**	**.37**	**.68**	**1.90**	**.42**	**.65**
	8 " 10	2.97	.22	.66	2.97	.22	.66	2.81	.25	.62	2.74	.28	.42	2.74	23	.42
¾ to 3 in.	½ to 1	1.39	.33	.86	1.35	.36	.84	1.30	.38	.81	1.25	.42	.76	1.21	.46	.71
	3 " 4	1.60	.31	.83	1.55	.34	.83	1.52	.36	.81	1.46	.41	.78	1.42	.44	.73
	6 " 7	**2.03**	**.27**	**.78**	**1.98**	**.29**	**.76**	**1.94**	**.32**	**.75**	**1.87**	**.36**	**.72**	**1.83**	**.38**	**.70**
	8 " 10	2.87	.21	.68	2.85	.21	67	2.75	.24	.69	2.69	.28	.68	2.64	.31	.66

* 1 barrel = 376 lb.

Proportions for 3,500 lb. per sq. in. Concrete.

[Based on 28-day compressive strength of 6 by 12 in. cylinders. Proportions are expressed by volume as follows: Portland cement: fine aggregate: coarse aggregate—Thus 1 : 2·6 : 4·6 indicates 1 part by volume of Portland cement, 2·6 parts by volume of fine aggregate, and 4·6 parts by volume of coarse aggregate.]

Size of Coarse Aggregate	Slump, in.	Proportions Using Fine Aggregate of Different Sizes				
		0-No. 30	0-No. 16	0-No. 8	0-No. 4	0-¾ in.
None	½ to 1	1:1.2	1:1.4	1:1.6	1:1.9	1:2.2
	3 " 4	1:1.0	1:1.1	1:1.3	1:1.5	1:1.8
	6 " 7	**1:0.6**	**1:0.8**	**1:0.9**	**1:1.0**	**1:1.2**
	8 " 10	1:0.3	1:0.4	1:0.4	1:0.5	1:0.6
No. 4 to ¾ in.	½ to 1	1:1.0:2.2	1:1.1:2.2	1:1.3:2.1	1:1.5:2.0	1:1.8:1.8
	3 " 4	1:0.8:1.9	1:0.9:1.9	1:1.0:1.8	1:1.2:1.7	1:1.4:1.5
	6 " 7	**1:0.5:1.3**	**1:0.6:1.4**	**1:0.6:1.3**	**1:0.8:1.3**	**1:0.9:1.2**
	8 " 10	1:0.2:0.7	1:0.2:0.7	1:0.3:0.7	1:0.3:0.7	1:0.4:0.6
No. 4 to 1 in.	½ to 1	1:0.9:2.6	1:1.0:2.6	1:1.2:2.5	1:1.4:2.4	1:1.6:2.3
	3 " 4	1:0.7:2.2	1:0.8:2.2	1:0.9:2.2	1:1.1:2.1	1:1.3:2.0
	6 " 7	**1:0.4:1.5**	**1:0.5:1.5**	**1:0.6:1.5**	**1:0.6:1.5**	**1:0.8:1.4**
	8 " 10	1:0.2:0.8	1:0.2:0.8	1:0.2:0.8	1:0.3:0.8	1:0.3:0.8
No. 4 to 1½ in.	½ to 1	1:0.9:2.9	1:1.0:2.9	1:1.1:2.9	1:1.3:2.8	1:1.5:2.7
	3 " 4	1:0.7:2.5	1:0.8:2.4	1:0.9:2.4	1:1.0:2.4	1:1.2:2.3
	6 " 7	**1:0.4:1.8**	**1:0.5:1.7**	**1:0.5:1.8**	**1:0.6:1.7**	**1:0.7:1.7**
	8 " 10	1:0.2:0.9	1:0.2:0.9	1:0.2:0.9	1:0.2:0.9	1:0.3:0.9
No. 4 to 2 in.	½ to 1	1:0.7:3.3	1:0.8:3.3	1:0.9:3.4	1:1.0:3.3	1:1.2:3.3
	3 " 4	1:0.6:2.8	1:0.6:2.8	1:0.7:2.8	1:0.8:2.8	1:1.0:2.8
	6 " 7	**1:0.3:2.0**	**1:0.4:2.0**	**1:0.4:2.0**	**1:0.5:2.0**	**1:0.6:2.0**
	8 " 10	1:0.1:1.0	1:0.1:1.0	1:0.2:1.0	1:0.2:1.0	1:0.2:1.0
⅜ to 1 in.	½ to 1	1:1.1:2.5	1:1.2:2.5	1:1.4:2.5	1:1.6:2.3	1:1.8:2.2
	3 " 4	1:0.8:2.1	1:0.9:2.1	1:1.1:2.1	1:1.3:2.0	1:1.5:1.9
	6 " 7	**1:0.5:1.5**	**1:0.6:1.5**	**1:0.7:1.5**	**1:0.8:1.4**	**1:0.9:1.4**
	8 " 10	1:0.2:0.8	1:0.2:0.8	1:0.3:0.8	1:0.3:0.8	1:0.4:0.7
⅜ to 1½ in.	½ to 1	1:1.0:2.8	1:1.2:2.8	1:1.3:2.8	1:1.6:2.7	1:1.8:2.6
	3 " 4	1:0.8:2.4	1:0.9:2.4	1:1.1:2.4	1:1.2:2.3	1:1.5:2.2
	6 " 7	**1:0.5:1.7**	**1:0.6:1.7**	**1:0.7:1.7**	**1:0.8:1.7**	**1:0.9:1.6**
	8 " 10	1:0.2:0.8	1:0.2:0.8	1:0.3:0.8	1:0.3:0.8	1:0.4:0.8
⅜ to 2 in.	½ to 1	1:1.0:3.2	1:1.1:3.2	1:1.2:3.2	1:1.4:3.2	1:1.6:3.1
	3 " 4	1:0.8:2.7	1:0.8:2.7	1:1.0:2.7	1:1.1:2.7	1:1.3:2.7
	6 " 7	**1:0.5:1.9**	**1:0.5:1.9**	**1:0.6:2.0**	**1:0.7:2.0**	**1:0.8:1.9**
	8 " 10	1:0.2:0.9	1:0.2:1.0	1:0.2:1.0	1:0.3:1.0	1:0.3:1.0
¾ to 1½ in.	½ to 1	1:1.3:2.6	1:1.4:2.7	1:1.6:2.6	1:1.9:2.6	1:2.2:2.4
	3 " 4	1:1.0:2.2	1:1.2:2.3	1:1.3:2.2	1:1.5:2.2	1:1.8:2.1
	6 " 7	**1:0.7:1.6**	**1:0.7:1.6**	**1:0.9:1.6**	**1:1.0:1.6**	**1:1.2:1.6**
	8 " 10	1:0.3:0.8	1:0.3:0.8	1:0.4:0.8	1:0.4:0.8	1:0.5:0.8
¾ to 2 in.	½ to 1	1:1.2:3.0	1:1.4:3.1	1:1.6:3.1	1:1.8:3.1	1:2.1:3.0
	3 " 4	1:1.0:2.5	1:1.1:2.6	1:1.2:2.6	1:1.5:2.6	1:1.7:2.5
	6 " 7	**1:0.6:1.8**	**1:0.7:1.8**	**1:0.8:1.9**	**1:0.9:1.9**	**1:1.1:1.9**
	8 " 10	1:0.3:0.9	1:0.3:0.9	1:0.3:0.9	1:0.4:0.9	1:0.5:0.9
¾ to 3 in.	½ to 1	1:1.2:3.4	1:1.3:3.4	1:1.5:3.4	1:1.7:3.3	1:2.0:3.3
	3 " 4	1:1.0:2.8	1:1.1:2.8	1:1.2:2.8	1:1.4:2.8	1:1.6:2.8
	6 " 7	**1:0.6:2.0**	**1:0.7:2.0**	**1:0.8:2.0**	**1:0.9:2.0**	**1:1.0:2.0**
	8 " 10	1:0.3:1.0	1:0.3:1.0	1:0.3:1.0	1:0.4:1.0	1:0.4:1.0

Quantities of Materials for 1 cu. yd. of 3,500 lb. per sq. in. Concrete.

[The volume of cement is expressed in barrels,* and of aggregates in cubic yards: F = fine aggregate; C = coarse aggregate. Quantities are net, no allowance being made for waste; for average conditions, the following additions are suggested: Cement, 2 per cent.; fine aggregate, 10 per cent.; coarse aggregate, 5 per cent.]

Size of Coarse Aggregate	Slump, in.	Quantities of Materials Using Fine Aggregate of Different Sizes											
		0-No. 30			0-No. 16			0-No. 8			0-No. 4			0-¾ in.		
		Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.
None	½ to 1	3.58	.64		3.38	.70		3.11	.74		2.71	.76		2.48	.81	
	3 " 4	3.90	.58		3.83	.62		3.51	.68		3.13	.70		2.81	.75	
	6 " 7	4.82	.43		4.34	.52		4.12	.55		3.79	.56		3.46	.61	
	8 " 10				5.00	.30		4.95	.29		4.48	.33		4.37	.30	
No. 4 to ¾ in.	½ to 1	2.08	.31	.68	2.06	.34	.67	2.01	.39	.63	1.91	.42	.57	1.92	.51	.51
	3 " 4	2.38	.28	.67	2.36	.31	.66	2.52	.37	.67	2.25	.40	.57	2.22	.46	.49
	6 " 7	3.08	.23	.59	3.02	.27	.63	2.96	.26	.57	2.88	.34	.56	2.83	.38	.50
	8 " 10	4.02	.12	.42	3.96	.12	.41	3.89	.17	.40	3.83	.17	.40	3.79	.22	.34
No. 4 to 1 in.	½ to 1	1.95	.26	.75	1.93	.29	.74	1.90	.34	.70	1.84	.38	.65	1.84	.43	.63
	3 " 4	2.27	.24	.74	2.25	.27	.73	2.18	.29	.71	2.15	.35	.67	2.10	.40	.62
	6 " 7	2.93	.17	.65	2.89	.21	.64	2.79	.25	.62	2.74	.24	.61	2.67	.32	.55
	8 " 10	3.88	.11	.46	3.82	.11	.45	3.79	.11	.45	3.68	.16	.44	3.67	.16	.43
No. 4 to 1½ in.	½ to 1	1.85	.25	.79	1.85	.27	.79	1.80	.29	.77	1.70	.33	.70	1.73	.38	.69
	3 " 4	2.14	.22	.79	2.11	.25	.75	2.05	.27	.73	1.97	.29	.70	1.98	.35	.67
	6 " 7	2.76	.22	.74	2.70	.20	.68	2.59	.19	.69	2.58	.23	.65	2.58	.27	.65
	8 " 10	3.79	.11	.50	3.69	.11	.49	3.67	.11	.49	3.72	.11	.50	3.80	.17	.51
No. 4 to 2 in.	½ to 1	1.79	.19	.87	1.77	.21	.86	1.71	.23	.86	1.68	.25	.87	1.65	.29	.81
	3 " 4	2.04	.18	.84	2.00	.18	.83	1.95	.20	.81	1.92	.23	.80	1.91	.28	.79
	6 " 7	2.62	.12	.78	2.60	.15	.77	2.52	.15	.75	2.50	.19	.74	2.50	.22	.74
	8 " 10	3.81	.06	.56	3.75	.06	.56	3.72	.11	.55	3.68	.11	.54	3.76	.11	.56
⅜ to 1 in.	½ to 1	2.02	.33	.75	1.94	.34	.72	1.88	.39	.69	1.85	.44	.63	1.79	.48	.58
	3 " 4	2.28	.27	.71	2.24	.30	.70	2.18	.35	.68	2.14	.41	.63	2.05	.45	.58
	6 " 7	2.86	.21	.64	2.84	.25	.63	2.76	.29	.61	2.74	.32	.57	2.66	.35	.55
	8 " 10	3.88	.11	.46	3.82	.11	.45	3.79	.17	.45	3.68	.16	.44	3.67	.22	.38
⅜ to 1½ in.	½ to 1	1.88	.28	.78	1.85	.33	.77	1.79	.34	.74	1.74	.41	.70	1.69	.45	.65
	3 " 4	2.16	.26	.77	2.10	.28	.75	2.04	.33	.73	1.98	.35	.67	1.93	.43	.66
	6 " 7	2.72	.20	.68	2.66	.24	.67	2.59	.27	.65	2.56	.30	.64	2.52	.34	.60
	8 " 10	3.79	.11	.45	3.69	.11	.44	3.67	.16	.43	3.40	.15	.40	3.31	.20	.39
⅜ to 2 in.	½ to 1	1.78	.26	.84	1.75	.28	.83	1.69	.30	.80	1.63	.36	.77	1.59	.38	.73
	3 " 4	2.03	.24	.81	1.98	.23	.79	1.93	.29	.77	1.91	.31	.76	1.84	.35	.73
	6 " 7	2.58	.19	.73	2.54	.19	.71	2.49	.22	.74	2.47	.26	.73	2.40	.28	.68
	8 " 10	3.80	.11	.51	3.73	.11	.55	3.64	.11	.54	3.68	.16	.54	3.56	.16	.53
¾ to 1½ in.	½ to 1	1.84	.35	.71	1.82	.38	.73	1.77	.42	.68	1.68	.47	.65	1.65	.54	.59
	3 " 4	2.13	.32	.69	2.09	.37	.71	2.02	.39	.66	1.85	.41	.60	1.89	.50	.59
	6 " 7	2.68	.28	.64	2.63	.27	.62	2.56	.34	.61	2.49	.37	.59	2.45	.44	.58
	8 " 10	3.79	.17	.45	3.69	.16	.43	3.67	.22	.43	3.72	.22	.44	3.66	.27	.43
¾ to 2 in.	½ to 1	1.76	.31	.78	1.72	.36	.79	1.67	.40	.77	1.58	.42	.72	1.55	.48	.69
	3 " 4	2.01	.30	.74	1.95	.31	.75	1.92	.34	.74	1.84	.41	.71	1.80	.45	.67
	6 " 7	2.58	.23	.69	2.54	.26	.68	2.48	.29	.70	2.40	.32	.68	2.35	.38	.66
	8 " 10	3.78	.17	.50	3.73	.17	.50	3.63	.16	.48	3.59	.21	.48	3.49	.26	.46
¾ to 3 in.	½ to 1	1.67	.30	.84	1.61	.31	.81	1.57	.35	.79	1.51	.38	.74	1.47	.43	.72
	3 " 4	1.91	.28	.79	1.86	.30	.77	1.93	.34	.80	1.76	.36	.73	1.71	.40	.71
	6 " 7	2.48	.22	.74	2.43	.25	.72	2.37	.28	.70	2.30	.31	.68	2.25	.33	.67
	8 " 10	3.64	.16	.54	3.57	.16	.53	3.52	16	.52	3.46	.20	.51	3.38	.20	.50

* barrel = 376 lb.

Proportions for 4,000 lb. per sq. in. Concrete.

[Based on 28-day compressive strength of 6 by 12 in. cylinders. Proportions are expressed by volume as follows: Portland cement: fine aggregate: coarse aggregate—Thus 1: 2·6: 4·6 indicates 1 part by volume of Portland cement, 2·6 parts by volume of fine aggregate, and 4·6 parts by volume of coarse aggregate.]

Size of Coarse Aggregate	Slump, in.	Proportions Using Fine Aggregate of Different Sizes				
		0-No. 30	0-No. 16	0-No. 8	0-No. 4	0-⅜ In.
None	½ to 1	1:0.9	1:1.1	1:1.2	1:1.5	1:1.7
	3 " 4	1:0.7	1:0.9	1:1.0	1:1.2	1:1.4
	6 " 7	**1:0.4**	**1:0.5**	**1:0.6**	**1:0.7**	**1:0.7**
	8 " 10	1:0.1	1:0.2	1:0.2	1:0.2	1:0.3
No. 4 to ¾ in.	½ to 1	1:0.8:1.8	1:0.9:1.8	1:1.0:1.8	1:1.2:1.7	1:1.4:1.5
	3 " 4	1:0.6:1.5	1:0.6:1.4	1:0.8:1.5	1:0.9:1.4	1:1.1:1.3
	6 " 7	**1:0.3:0.9**	**1:0.4:1.0**	**1:0.4:0.9**	**1:0.5:0.9**	**1:0.6:0.9**
	8 " 10	1:0.1:0.3	1:0.1:0.3	1:0.1:0.3	1:0.1:0.3	1:0.2:0.3
No. 4 to 1 in.	½ to 1	1:0.7:2.1	1:0.8:2.1	1:0.9:2.1	1:1.0:2.0	1:1.2:1.9
	3 " 4	1:0.5:1.7	1:0.6:1.6	1:0.7:1.7	1:0.8:1.7	1:0.9:1.6
	6 " 7	**1:0.3:1.1**	**1:0.3:1.1**	**1:0.4:1.1**	**1:0.4:1.1**	**1:0.5:1.1**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4
No. 4 to 1½ in.	½ to 1	1:0.6:2.4	1:0.7:2.4	1:0.8:2.4	1:1.0:2.3	1:1.1:2.2
	3 " 4	1:0.5:2.0	1:0.5:1.9	1:0.6:2.0	1:0.7:1.9	1:0.9:1.9
	6 " 7	**1:0.3:1.2**	**1:0.3:1.2**	**1:0.3:1.2**	**1:0.4:1.2**	**1:0.4:1.2**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4
No. 4 to 2 in.	½ to 1	1:0.5:2.7	1:0.6:2.7	1:0.7:2.7	1:0.8:2.7	1:0.9:2.8
	3 " 4	1:0.4:2.2	1:0.4:2.2	1:0.5:2.3	1:0.6:2.3	1:0.7:2.3
	6 " 7	**1:0.2:1.4**	**1:0.2:1.4**	**1:0.3:1.4**	**1:0.3:1.5**	**1:0.3:1.4**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.1:0.5	1:0.1:0.5	1:0.1:0.5
⅜ to 1 in.	½ to 1	1:0.8:2.1	1:0.9:2.0	1:1.0:2.0	1:1.2:1.9	1:1.4:1.8
	3 " 4	1:0.6:1.7	1:0.7:1.7	1:0.8:1.6	1:0.9:1.6	1:1.1:1.5
	6 " 7	**1:0.3:1.1**	**1:0.4:1.1**	**1:0.4:1.0**	**1:0.5:1.0**	**1:0.6:1.0**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.2:0.4
⅜ to 1½ in.	½ to 1	1:0.8:2.3	1:0.9:2.3	1:1.0:2.3	1:1.2:2.3	1:1.4:2.2
	3 " 4	1:0.6:1.9	1:0.7:1.9	1:0.8:1.9	1:0.9:1.9	1:1.1:1.8
	6 " 7	**1:0.3:1.2**	**1:0.4:1.2**	**1:0.4:1.2**	**1:0.5:1.2**	**1:0.6:1.2**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.1:0.4	1:0.2:0.4
⅜ to 2 in.	½ to 1	1:0.7:2.6	1:0.8:2.6	1:0.9:2.6	1:1.0:2.6	1:1.2:2.6
	3 " 4	1:0.6:2.1	1:0.6:2.2	1:0.7:2.2	1:0.8:2.2	1:1.0:2.2
	6 " 7	**1:0.3:1.4**	**1:0.3:1.4**	**1:0.4:1.4**	**1:0.4:1.4**	**1:0.5:1.4**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.1:0.5	1:0.1:0.4	1:0.1:0.5
¾ to 1½ in.	½ to 1	1:1.0:2.2	1:1.1:2.2	1:1.3:2.2	1:1.5:2.1	1:1.7:2.0
	3 " 4	1:0.8:1.8	1:0.9:1.8	1:1.0:1.8	1:1.2:1.8	1:1.3:1.7
	6 " 7	**1:0.4:1.1**	**1:0.5:1.1**	**1:0.6:1.2**	**1:0.7:1.1**	**1:0.8:1.1**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.2:0.4	1:0.2:0.4	1:0.2:0.4
¾ to 2 in.	½ to 1	1:0.9:2.5	1:1.0:2.5	1:1.2:2.5	1:1.4:2.5	1:1.6:2.5
	3 " 4	1:0.7:2.0	1:0.8:2.1	1:0.9:2.1	1:1.1:2.1	1:1.3:2.1
	6 " 7	**1:0.4:1.3**	**1:0.5:1.3**	**1:0.5:1.4**	**1:0.6:1.4**	**1:0.7:1.3**
	8 " 10	1:0.1:0.4	1:0.1:0.4	1:0.2:0.4	1:0.2:0.4	1:0.2:0.4
¾ to 3 in.	½ to 1	1:0.9:2.7	1:1.0:2.7	1:1.2:2.8	1:1.3:2.7	1:1.5:2.7
	3 " 4	1:0.7:2.2	1:0.8:2.3	1:0.9:2.3	1:1.0:2.3	1:1.2:2.2
	6 " 7	**1:0.4:1.4**	**1:0.4:1.4**	**1:0.5:1.5**	**1:0.6:1.5**	**1:0.7:1.5**
	8 " 10	1:0.1:0.5	1:0.1:0.5	1:0.1:0.5	1:0.2:0.5	1:0.2:0.5

Quantities of Materials for 1 cu. yd. of 4,000 lb. per sq. in. Concrete.

[The volume of cement is expressed in barrels,* and of aggregates in cubic yards: F = fine aggregate; C = coarse aggregate. Quantities are net, no allowance being made for waste; for average conditions, the following additions are suggested: Cement, 2 per cent.; fine aggregate, 10 per cent.; coarse aggregate, 5 per cent.]

Size of Coarse Aggregate	Slump, in.	Quantities of Materials Using Fine Aggregate of Different Sizes											
		0-No. 30			0-No. 16			0-No. 8			0-No. 4			0-¾ in.		
		Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F.	Aggregate C.	Cement	Aggregate F	Aggregate C.
None	½ to 1	4.21	.56		3.91	.65		3.75	.79		3.19	.71		2.96	.75	
	3 " 4	4.64	.48		4.25	.57		4.03	.60		3.57	.64		3.27	.68	
	6 " 7	5.05	.30		5.21	.39		4.89	.44		4.36	.45		4.41	.46	
	8 " 10													4.78	21	
No. 4 to ¾ in.	½ to 1	2.46	.29	.65	2.44	.32	.65	2.39	.35	.64	2.33	.41	.59	2.30	48	.51
	3 " 4	2.86	.25	.64	2.80	.25	.58	2.74	.32	.61	2.64	.35	.55	2.61	42	.50
	6 " 7	3.68	.16	.49	3.67	.22	.54	3.62	.21	.48	3.56	.26	.48	3.54	.23	.34
	8 " 10	4.79	.06	.43	4.79	.07	.23	4.77	.08	.23	4.76	.10	23	4.74	11	.22
No. 4 to 1 in.	½ to 1	2.36	.24	.73	2.32	.27	.72	2.27	.30	.71	2.21	.33	.65	2.18	.39	.61
	3 " 4	2.71	.20	.68	2.65	.24	.63	2.58	.27	.65	2.56	.30	.64	2.54	.34	.60
	6 " 7	3.59	.16	.58	3.58	.16	.58	3.51	.21	.57	3.46	.20	.56	3.48	.26	.57
	8 " 10	4.79	.05	.25	4.76	.05	.26	4.73	.07	.26	4.70	.08	.26	4.69	.09	.26
No. 4 to 1½ in.	½ to 1	2.25	.20	.80	2.21	.23	.78	2.15	.25	.76	2.03	.30	.69	2.05	.33	.67
	3 " 4	2.56	.19	.76	2.64	.19	.71	2.46	.22	.73	2.43	.25	.68	2.42	.32	.68
	6 " 7	3.48	.15	.62	3.47	.15	.62	3.39	.15	.60	3.34	.20	.59	3.34	.20	.59
	8 " 10	4.69	.04	.28	4.69	.05	.28	4.69	.06	.29	4.67	.07	.29	4.67	.08	.29
No. 4 to 2 in.	½ to 1	2.14	.16	.86	2.10	.19	.84	2.03	.21	.81	2.00	.24	80	1.91	.26	.79
	3 " 4	2.47	.15	.80	2.45	.15	.80	2.37	.18	.81	2.33	.21	.79	2.31	.24	.78
	6 " 7	3.36	.10	.70	3.33	.10	.66	3.24	.14	.67	3.19	.14	.71	3.20	.14	.66
	8 " 10	4.69	.03	.31	4.68	.03	.30	4.67	.04	.32	4.61	.04	.33	4.54	.05	.33
⅜ to 1 in.	½ to 1	2.36	.29	.73	2.32	.31	.69	2.26	.33	.67	2.22	.39	.62	2.13	.44	.57
	3 " 4	2.65	.24	.67	2.62	.27	.66	2.58	.31	.61	2.54	.34	.60	2.48	.40	.55
	6 " 7	3.42	.15	.56	3.39	.20	.55	3.33	.20	.49	3.30	.24	.49	3.23	.29	.48
	8 " 10	4.79	.06	.26	4.76	.07	.25	4.73	.08	.26	4.70	.10	.25	4.69	.12	.24
⅜ to 1½ in.	½ to 1	2.26	.27	.77	2.20	.29	.75	2.14	.32	.73	2.08	.37	.71	2.00	.41	.65
	3 " 4	2.54	.23	.71	2.51	.26	.71	2.48	.29	.70	2.42	.32	.68	2.36	.38	.63
	6 " 7	3.24	.14	.58	3.17	.19	.56	3.16	.19	.56	3.10	.23	.55	3.13	.28	.56
	8 " 10	4.69	.06	.28	4.69	.07	.28	4.69	08	.28	4.67	.09	.28	4.67	.11	.28
⅜ to 2 in.	½ to 1	2.14	.22	.82	2.08	.25	.80	2.01	.27	.77	1.98	.29	76	1.92	.34	.74
	3 " 4	2.46	.22	.76	2.42	.21	.79	2.34	.24	76	2.31	.27	.75	2.22	.33	.72
	6 " 7	3.14	.14	.65	3.07	.14	.64	3.02	.18	.63	3.02	.18	.63	2.98	.22	.62
	8 " 10	4.69	.05	.30	4.68	.06	.30	4.67	.07	.32	4.61	.08	.31	4.54	.08	.31
¾ to 1½ in.	½ to 1	2.23	.33	.72	2.18	.35	.71	2.12	.41	.69	2.01	.45	.62	1.95	.49	.58
	3 " 4	2.53	.30	.68	2.49	.33	.66	2.44	.36	.65	2.42	.43	.65	2.29	.44	.58
	6 " 7	3.18	.19	.52	3.12	.23	.51	3.03	.27	.54	2.97	.31	.48	2.98	.35	.49
	8 " 10	4.69	.08	.26	4.69	.10	.27	4.69	.11	.28	4.67	.12	.28	4.67	.15	.27
¾ to 2 in.	½ to 1	2.11	.28	.78	2.05	.30	.76	1.99	.35	.74	1.91	.40	.71	1.88	.44	.69
	3 " 4	2.44	.25	.72	2.39	.28	.74	2.34	.31	.73	2.24	.36	.70	2.18	.42	.68
	6 " 7	3.12	.18	.60	3.11	.23	.60	3.00	.22	.62	2.94	.26	.61	2.90	.30	.56
	8 " 10	4.69	.08	.29	4.68	.09	.30	4.67	.10	.30	4.61	.11	.30	4.54	.13	.30
¾ to 3 in.	½ to 1	1.98	.25	.79	1.94	.29	.77	1.90	.34	.79	1.84	.35	74	1.78	.40	.71
	3 " 4	2.33	.24	.76	2.28	.27	.78	2.21	.30	.75	2.12	.31	.72	2.06	.37	.67
	6 " 7	3.00	.18	.62	2.97	.18	.62	2.96	.22	.66	2.90	.26	.64	2.77	.29	.62
	8 " 10	4.60	.08	.32	4.54	08	32	4.49	.09	.32	4.44	.10	.32	4.43	12	.32

* 1 barrel = 376 lb.

CHAPTER 5.

SURFACE TREATMENT OF CONCRETE.

THE practice in treating concrete surfaces may be divided under two heads: (1) Removing the film of cement from the surface of the concrete and exposing the aggregate, and (2) adding colouring materials to the concrete while it is being mixed.

EXPOSED AGGREGATE.

Under the first heading, a great variety of colour effects may be obtained by the judicious use of different coloured aggregates, such as marble chippings of various colours and sizes, different coloured gravels and sands, red or blue granite, or combinations of these in varying proportions.

The cost of these coloured aggregates for the whole of the exterior walling of a large structure would generally be prohibitive, and when this is the case the usual practice is to use ordinary concrete for the body of a wall and the coloured aggregate, say, 1 in. thick, for the outside of the wall. The two thicknesses of the wall are erected at the same time, a board or steel form being used to keep the concretes apart whilst they are being poured, and raised upwards as the work proceeds, so that the two thicknesses of the wall will bond together and become monolithic. After the erection of the wall the film of cement is removed by one of three methods, viz., scrubbing, tooling, or sand-blasting.

The removal of the mortar film by brushing is best performed after the concrete has set but while it is still green, and to this end the forms must be removed as soon as may be done without injury to the structure. How soon this may be will depend upon the character of the structure, the consistency of the mixture, and the weather. No definite rule can be laid down, but in cold weather it is necessary to keep the forms in position much longer than in hot weather.

An ordinary scrubbing brush or a wire brush used with a liberal application of clean water will generally serve the purpose if the concrete is not too hard, but if it is found that the colour of the aggregate is not fully brought out by this treatment a solution of hydrochloric acid diluted with three or four parts of water may be employed. Where this is done care must be taken that every trace of the acid is immediately removed from the surface of the concrete by well washing with clean water, preferably by means of a hose. By this method the aggregate is brought into semi-relief and its colour fully revealed.

Where shuttering cannot be removed before the concrete is too hard for this treatment another method is available, viz., that of bush-hammering. The action of the bush-hammer produces an effect similar to that obtained in the process of brushing, by cutting away the cement mortar and leaving the aggregate exposed. If necessary, the acid solution may be used as a clearing agent to supplement the effect of the tooling. This form of treatment should not be applied until the concrete is thoroughly hard, say in six or eight weeks ; otherwise there is a danger that, instead of the film of mortar only being removed, the particles of the aggregate itself may be dislodged, leaving unsightly pits.

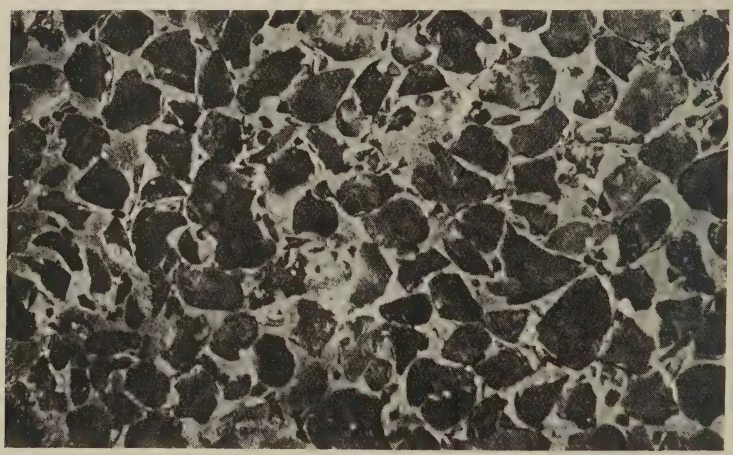
Sand-blasting is another means by which the same purpose may be effected when the concrete is hard. In this process a fine stream of sand is forced through the nozzle of a compressed-air machine, and, by impinging sharply upon the concrete surface, removes the mortar from the face of the aggregate.

In order to prevent the concrete sticking to the forms, the face of the boards which are to come in contact with the concrete should be slightly oiled, either with a rag moistened with paraffin or with one of the special oils supplied for this purpose.

Where the area to be treated is large, it will greatly add to the appearance of the surface if it is broken up by courses, or into panels ; during concreting care should be taken to ensure that work is only stopped at a joint or a course, since it is difficult to join new work on to that which has already set in such a way that the junction is not perceptible.

An excellent finish was obtained on a building erected last year by rendering the walls with a mixture composed of white and black marble chippings and Portland cement in the proportion of 2 : 1. The marble chippings were graded into three sizes, namely, No. 0, $\frac{1}{8}$ in. ; No. 1, $\frac{1}{4}$ in. ; No. 2, $\frac{3}{8}$ in. to $\frac{7}{16}$ in., and mixed in the following proportions :

Concrete Surface with Pit Ballast Aggregate Exposed (One-third actual size).



Concrete Surface with Crushed Ballast Aggregate Exposed (One-third actual size).

Figs. 7 and 8.—SURFACE TREATMENTS FOR CONCRETE.

Per cent.		Size.
34	White marble chippings	2
22	,, ,, ,, ...	1
11	,, ,, ,, ...	0
17	Black ,, ,, ...	2
8	,, ,, ,, ...	1
8	,, ,, ,, ...	0
100		

The specification for the rendering was as follows :—" Score the breeze blocks and wet them. Put on a $\frac{1}{4}$-in rendering of 2 : 1 cement and sand, and after this has stiffened sufficiently put on another $\frac{1}{4}$-in. rendering of marble chips in the proportion of 2 parts chips to 1 of cement, and press into first rendering. Twenty-four hours later scrub the cement off the surface, exposing the marble."

COLOURING MATERIALS.

When colouring materials are used they should be thoroughly mixed with the cement before it is added to the coarse material, and care should be taken to ensure that the colour and cement are thoroughly mixed together.

If any particular shade is required it is advisable to make up some trial mixtures in order to ascertain the correct proportions necessary to produce the desired shade ; the proportions and colouring materials given below will, however, form a useful guide from which different shades may be produced :

RED.

86 parts finely ground Portland cement.
14 ,, red oxide of iron (ferric oxide).

YELLOW.

88 parts finely ground Portland cement.
12 ,, yellow ochre.
Alternative :—90 parts finely ground Portland cement.
10 ,, barium chromate.

BLUE.

86 parts finely ground Portland cement.
14 ,, azure blue or ultramarine.

GREEN.

90 parts finely ground Portland cement.
10 ,, oxide of chromium.

Concrete Surface with Exposed Aggregate of Various Coloured Marble Chippings (One-third actual size).

Concrete Surface with Exposed Aggregate, Black and White Marble Chippings (One-third actual size).

Figs. 9 and 10.—SURFACE TREATMENTS FOR CONCRETE.

CHOCOLATE.

88 parts finely ground Portland cement.
6 ,, black oxide of manganese.
4 ,, red oxide of iron.
2 ,, black oxide of iron or copper.

BLACK.

90 parts finely ground Portland cement.
10 ,, black oxide of manganese or any carbon black.

PINK.

97 parts finely ground Portland cement.
3 ,, best quality crimson lake (alumina base).

RENDERING.

Some attractive finishes may be obtained by rendering with a Portland cement mortar in which coloured sands are employed. This method admits of almost unlimited scope for the display of the craft and individuality of the plasterer, and many pleasing trowelled, pebble-dash, spatter-dash and other finishes are possible by its use.

AMERICAN METHODS OF SURFACE FINISHING.

A Committee of the American Concrete Institute which has considered the question of the treatment of concrete surfaces issued its report last year. The different treatments recommended are divided into five general classes, namely:

(1) Pointing and patching.
(2) Correction of column and beam lines, joints, etc.
(3) Cement washes and proprietary paints.
(4) Rubbed finishes.
(5) Tooled finishes.

The section on pointing and patching outlines what might be described as the minimum cleaning up of the surface necessary to make a structure at all presentable, such as filling bolt holes, rubbing down any ridges left where the shuttering has not fitted closely, etc. The processes mentioned in this section are, in fact, those which would in any case be seen to, apart altogether from the æsthetic aspect, for without they were carried out no reinforced concrete building could be considered a structurally sound job.

The second section goes a step further, and deals with matters which again are attended to as a matter of course on practically all concrete buildings, such as protecting any reinforcement which has

been allowed to protrude, cutting to line any columns which are out of plumb or beams which sag, and rubbing down small projections. In this connection it is pointed out that it is better, quicker, and cheaper to pound off such projections with a flat-headed hammer than to cut them away with a chisel.

Cement Washes.—The application of cement washes and concrete paints is dealt with at some length, and it is pointed out that cement washes of practically any colour from cream to grey can be prepared by varying the proportions used of light coloured or grey cement and light or dark sand. After the cement and sand in the desired proportions are thoroughly mixed in the dry state, the mixture should be added slowly to water, stirring vigorously until the consistency is that of a stiff oil paint. The dry batch should be large enough for a full day's work, but only enough of the wash should be prepared to last one hour. The wash should be fully stirred in the container before each application to the concrete surface, and when refilling the container all the old wash should be cleaned out and discarded. The area to be coated should first be thoroughly wet, and then a full brush coat of the wash applied. This coat should be rubbed in with a cork float, the surface being sprinkled with a little additional water if necessary. Finally the surface should be gone over with a clean damp brush, brushing in the direction of the board marks. In this process all excess material should be removed, and the remaining coat should be as thin as will permit the surface to be entirely covered. In warm or drying weather the finished surface should be sprinkled with water once a day for three days, and in cool, damp weather should be sprinkled at least once within 24 hours after finishing.

The sand must be dry before screening, not only to facilitate the screening, but also to avoid the possibility of moisture in the sand causing a set in the dry mix. Best results seem to be obtained with a No. 18 sieve.

A very fine appearance is obtained if the wash is rubbed in with a carborundum stone. This not only ensures a better bond, by more positively forcing the material into the pores of the concrete, but at the same time grinds down any slight projection, leaving a semi-rubbed surface.

Sprinkling of the freshly-coated surface is necessary, for if the wash dries before it has attained its set, it will dust off. The sprinkling must be gentle so as not to wash off the fresh coating.

The Committee has been informed that a very effective way of

ensuring the bond of the wash coat is to use a 4 per cent. solution of commercial calcium chloride as the gauging liquid instead of plain water. This solution is made up by dissolving 1 lb. of the chloride in 3 galls. of water. The calcium chloride attracts moisture from the air and keeps the wash coat damp for several days, thus ensuring that the cement sets before it dries out.

The cement wash will cost about 1*d.* per sq. ft., and will require about one cubic ft. of cement per 1,000 sq. ft.

Rubbed Finishes.—The rubbed finishes are obtained with carborundum stones. It is recommended that the first rub should be completed as soon as the forms can be removed; faces and sides of columns should be stripped in 24 hours if possible, and the soffits of beams should be treated within three or four days. As soon as the forms are removed the surface should be thoroughly wetted and then rubbed with a No. 20 carborundum stone. The rubbing will remove board marks, nailhead marks, and to a certain extent the irregularities between boards.

The cement paste which works up in the rubbing process should be removed by washing and brushing. Small voids in the concrete should be filled with a mortar (usually 1 : 2) composed of finely-screened aggregate of the same general description as that used in the concrete. This mortar should be worked into the face with the carborundum stone and left even and regular.

It is stated that the best and most economical results are obtained by applying the first rub to the concrete while it is green. Filling the small voids with mortar offers no difficulties, but the operator should be warned against leaving an appreciable thickness of mortar on the face of the concrete to take up irregularities in the surface, unless special precautions are taken to ensure the bond. Such precautions are particularly necessary when the surfacing is delayed until the concrete has hardened and dried out.

If the concrete cannot be given the first rub when it is still green, board marks, nailhead marks, and small projections must first be removed. After thorough wetting, the surface should be coated with a cement wash in order to help the grinding action. The carborundum rub should then be given, taking care to remove all the cement wash by washing and brushing.

The second rub should be applied near the end of the work, when the building is ready to clean down and danger of staining from other work is past. The surface should be thoroughly wetted, and then gone over with a No. 24 carborundum stone. The paste which is

worked up should be removed with a wet brush, and when dry the finished surface will resemble limestone in colour and texture.

The cost of this process, including miscellaneous pointing and first and second rub, should cost about 3*d*. per sq. ft.

Tooled Finishes.—This heading includes all finishes in which the surface of the concrete is mechanically roughened, or removed to expose the aggregate. Wire brushes, stone dressing tools, and rotary cutters are used for this purpose.

When coarse aggregate is to be exposed by wire brushing, the concrete should be as green as possible, usually not over 48 hours old. Generally speaking, this process is not practicable on large buildings unless special effects are to be obtained, in which case the treatment, if it is to be successful, requires careful preparation and selection of aggregates, as well as extreme care in concreting.

When bush-hammering or other tooling treatment is to be used, attention should be given to the proper lay-out of construction joints and fill lines, and plans showing the treated areas should be issued before any concrete is placed. The work should be planned to eliminate as many joints as possible, particularly horizontal fill lines. If the latter are unavoidable they should be absolutely level.

Where coarse aggregate is to be exposed by picking or hammering, it should be of uniform size or uniformly graded. The distribution of the aggregate should also be uniform for satisfactory results, and the consistency of the mix should, therefore, be carefully controlled in order to prevent the settling or segregation of aggregate.

When patching or filling of bolt holes is required on an area which is to receive a tooled finish, the tooling should precede the patching. The latter should then be done by a skilled workman who should match the texture of the surrounding area by imbedding selected pieces of large aggregate in a mortar bed.

Surfaces to be finished with a rough texture should be at least two weeks old before finishing. The work may be executed by mechanical devices operated by air or electricity, or by hand-hammering. In general the work on any one panel or area should be done by the same operator in order to avoid differences in texture.

As the tooled finishes are usually carried out in panel effects, great care should be taken to lay out exact lines and to cut clean and sharp at the edges. The borders of the panels and such other parts of the surface as are not roughened must receive a washed or rubbed finish, to balance with the tooled areas.

In the Committee's opinion the effects that are possible under the

various tooling treatments are the most pleasing of any. The success of tooling depends upon uniformity in the results obtained, and, therefore, special attention is called to the importance of avoiding joints, fill lines, laitance and segregation. Careful selection of aggregate helps in attaining the desired uniformity, and if the aggregate be selected for colour, its exposure by tooling will introduce a variation of effects in colour as well as in texture.

CHAPTER 6.

CONCRETING IN COLD WEATHER.

The necessity of taking every precaution for the protection of concrete work in progress in the winter months cannot be too strongly emphasised. Providing adequate methods are adopted for heating the materials and covering the work so soon as it is laid, there is no reason (except, perhaps, extra cost) why concrete construction should not proceed during the most severe weather. In winter, frosts are expected and prepared for, but the bright spring days are very liable to engender carelessness. It has to be remembered, however, that in the early part of the year, warm, sunny days are often followed by sharp frosts during the night, which play havoc with work not properly protected. The motto should be "Prevention is better than cure"—a little trouble in covering up is much easier and less expensive than cutting away and making good.

Although it is now generally recognised that the setting of cement is a chemical action evolving heat, which is manifested by raising the temperature of the cement, probably few appreciate the value of this heat in preserving concrete in winter weather from the attack of frost, and some investigations upon the rate of cooling of fresh concrete in freezing weather, carried out recently at the University of Illinois Engineering Experiment Station, are worthy of consideration.

The method of experiment consisted in casting concrete blocks 12 in. by 12 in. horizontal section and of depths varying from 4 in. to 20 in. in moulds of 1½-in. pine boards, the moulds being contained in another wooden box 3 ft. square and 3 ft. deep, and the intervening spaces between the mould and the outer box being filled with sawdust. Thermo-couples were inserted in the concrete at various depths from the surface, and the insulated moulds containing the concrete were placed within 20 minutes of mixing in a cold storage room at −10 deg. C. The concrete blocks were thus exposed to the cold on one surface only, all other surfaces being well insulated. Temperatures recorded by the thermo-couples were observed at intervals.

Typical curves of cooling are shown in *Fig.* 11, from which it will

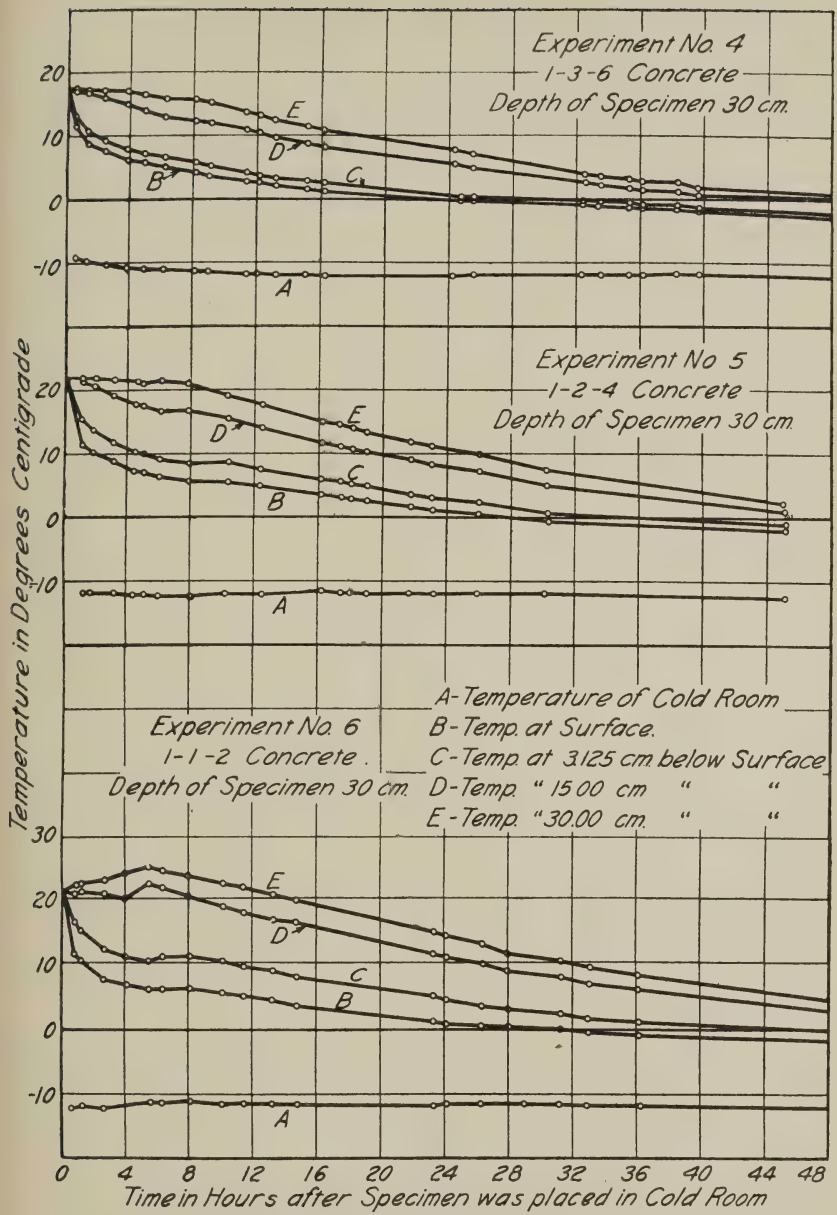

Experiment No. 4
1-3-6 Concrete
Depth of Specimen 30 cm.
Experiment No. 5
1-2-4 Concrete
Depth of Specimen 30 cm.
Experiment No. 6
1-1-2 Concrete.
Depth of Specimen 30 cm.
A-Temperature of Cold Room
B-Temp. at Surface.
C-Temp. at 3.125 cm. below Surface
D-Temp. " 15.00 cm " "
E-Temp. "30.00 cm. " "
Temperature in Degrees Centigrade
Time in Hours after Specimen was placed in Cold Room

FIG. 11.—CURVES OF COOLING EXPERIMENTS 4, 5 AND 6.

be seen that starting with a concrete at 20 deg. C. (68 deg. F.) in a temperature of −10 deg. C. (14 deg. F.), the freezing point at the surface is not reached until after a lapse of 24 hours, while at 15 cm. (6 in.) below the surface freezing point is not reached under 40 hours. That this is not due altogether to a naturally slow rate of cooling

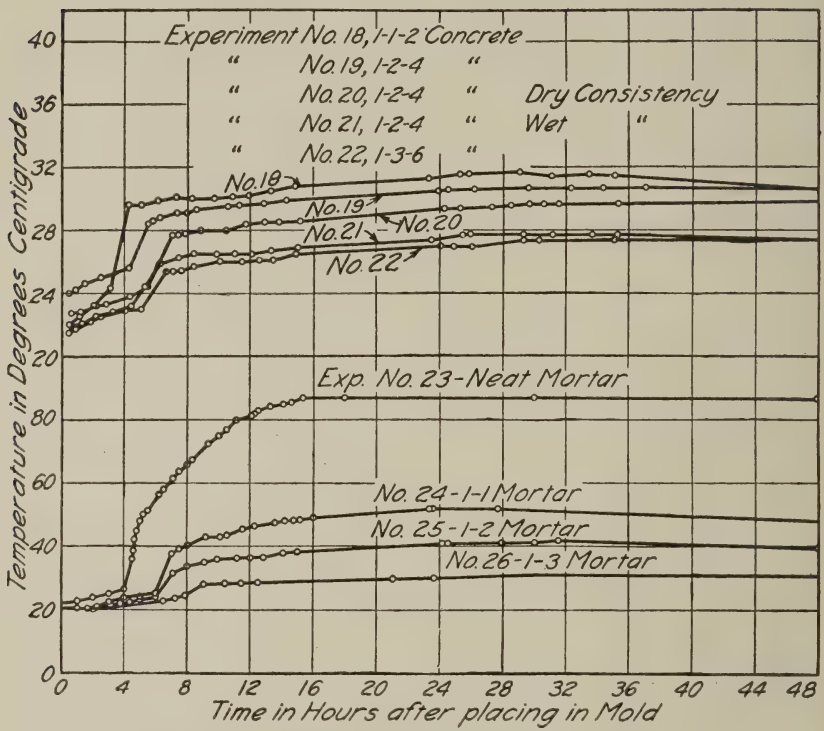


Fig. 12.—Diagram showing Rise in Temperature during Setting of Concrete and Mortar.

is seen by reference to *Fig.* 12, which shows the rise in temperature in 12-in. cubes of concrete kept at ordinary laboratory temperature and insulated on all six sides.

The practical conclusion to be drawn from these observations is that the heat generated during the setting of concrete should be conserved to help the concrete to resist the action of frost. The effect

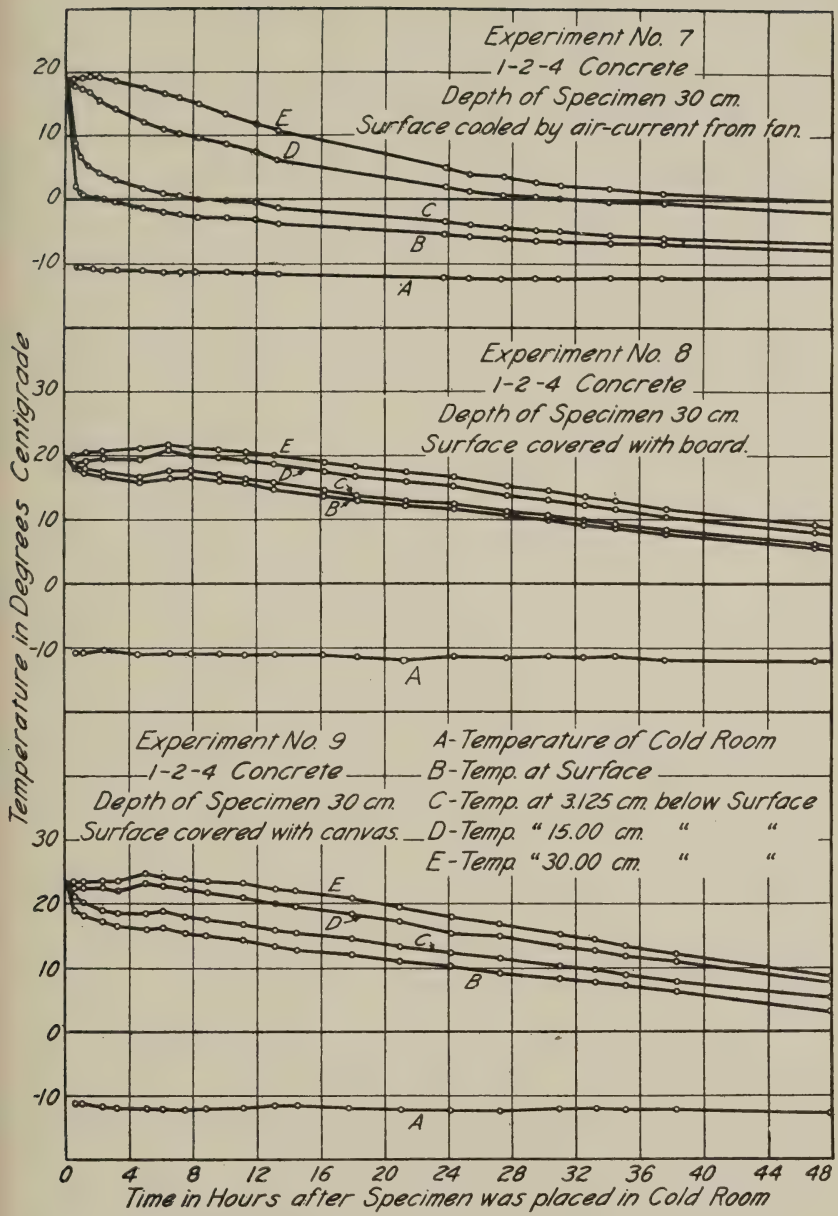

Experiment No. 7
1-2-4 Concrete
Depth of Specimen 30 cm.
Surface cooled by air-current from fan.
Experiment No. 8
1-2-4 Concrete
Depth of Specimen 30 cm.
Surface covered with board.
Experiment No. 9
1-2-4 Concrete
Depth of Specimen 30 cm.
Surface covered with canvas.
A-Temperature of Cold Room
B-Temp. at Surface
C-Temp. at 3.125 cm. below Surface
D-Temp. " 15.00 cm. " "
E-Temp. " 30.00 cm. " "
Temperature in Degrees Centigrade
Time in Hours after Specimen was placed in Cold Room
0 4 8 12 16 20 24 28 32 36 40 44 48
20 10 0 -10
30 20 10 0 -10
30 20 10 0 -10

FIG. 13.—CURVES OF COOLING EXPERIMENTS 7, 8 AND 9.

of so doing is cumulative, because by maintaining a high temperature within the concrete, the harder it becomes, and the harder the concrete the less it can be harmed by frost. In this connection the results of further experiments recorded graphically in *Fig.* 13 are of interest. Here it will be observed from the results of Experiment No. 7 that a concrete surface submitted to an air current of 10 miles per hour in a cold storage chamber at −10 deg. C. cooled much more rapidly than a concrete in still air (cp. Experiment No. 5), while covering with wood or canvas was of great value in retaining the heat of the concrete, as even the surface temperature of the concrete did not descend to freezing point in 48 hours. It should be noted, however, that in these cases care was taken to prevent circulation of air below the covering.

In drawing conclusions from these experiments it needs to be emphasised that the concrete was at a fairly high temperature when mixed—viz. about 68 deg. F.—and if concreting is to be done successfully in frosty weather it is necessary to heat the materials of which it is composed. This being done, it is evident that by protection of the concrete on all sides by means such as shuttering, there is little danger to be apprehended from any low temperature likely to occur in this country.

The experimental results are mathematically analysed and applied with the idea of predicting the temperature of freshly laid concrete subjected to frost. For example, it is calculated that mass concrete within shuttering and with one exposed surface, if at a commencing temperature of 60 deg. F. and in still air at 10 deg. F., would not reach freezing point at the surface for 18 hours, while at 12 hours the surface temperature would be 35 deg. F., and the temperature 4 in. below the surface 45 deg. F. If the surface of the concrete be covered with a board 1 in. thick, the surface temperature after 72 hours is calculated at 35 deg. F. If the concrete is in the form of a thin wall or slab the rate of cooling is greater, and it is calculated, for example, that in a 16-in. wall between $\frac{3}{4}$-in. shuttering with concrete at a commencing temperature of 60 deg. F., the temperature at the surface 36 hours after pouring will be 36 deg. F., and at the centre of the wall, 41 deg. F., after the same lapse of time, when the atmosphere is at 10 deg. F.

Another purpose for which the data upon the subject may be used is to calculate the temperature to which the concrete materials must be heated to prevent freezing occurring in a given time at a given atmospheric temperature.

CHAPTER 7.

REINFORCED CONCRETE AND FIRE RESISTANCE.

The assessment of the fire risks appertaining to various methods of construction must necessarily be based largely on experience, and as such experience in the large range that is desirable is generally not obtained for several years after any new constructional system has been introduced, it follows that there is a tendency for the ideas on which fire risks are assessed to be somewhat out of date. Under these circumstances, the tests of the fire resistance of various systems of construction carried out by the British Fire Prevention Committee, the United States Bureau of Standards and others, are of considerable importance and need to be strongly emphasised if the results of such tests show that current ideas of fire risk surveyors are not in line with reasonable deductions from the experiments.

British fire insurance offices appear to have adopted a system of rebates in premiums to coincide with certain reductions in the fire risk, the allowances ranging from 10 per cent. to 40 per cent. under four standards, but so far as the building construction is concerned, the allowance is the same so long as structural metal is protected by bricks, terra-cotta, concrete, etc., practically the only distinction being between an unprotected steel structure—for which no rebate is made—and protected steel structures, which include reinforced concrete. The chief considerations which govern the inclusion of a building in any one of the four standards mentioned—apart, of course, from the nature of the contents, which is of prime importance—are dimensions, openings, flues, etc., and material of construction is regarded as of lesser importance.

The most recent experimental evidence available is to be seen in a publication of the United States Bureau of Standards (Technologic Paper No. 184), where are given results of fire tests of 106 building columns conducted at the Underwriters' Laboratory in conjunction with Fire Insurance Companies and Fire Underwriters. Among the

four classes of columns tested were (1) reinforced concrete and (2) steel protected by 2 in. or 4 in. of concrete, hollow tile, brick, etc., and the results should accordingly refute or confirm the belief that fire insurance surveyors would be justified in allowing a rebate in premium for buildings of class (1) compared with those of class (2).

The reinforced concrete columns tested were 12 ft. 8 in. long by 16 in. square or 17 in. diameter, the concrete being 1 : 2 : 4 and containing various aggregates. The reinforcement was of the usual types and the columns were designed for a working load of 100,000 lb. During the tests the columns were subjected to a constant working load and the temperature was regulated to reach 1,700 deg. F. at one hour, 2,000 deg. F. at 4 hours, and 2,300 deg. F. at 8 hours.

The results demonstrate that reinforced concrete columns were the most fire resistant, and showed a marked superiority in this respect to protected steel columns, as will be seen from the following tabulation :

	Time at which failure occurred.
Reinforced concrete . . .	7 hrs. 23 mins. to 8 hrs. 40 mins.
Steel with brick protection . .	1 hr. 40 mins. to 7 hrs. 13 mins.
,, ,, hollow tile protection .	50 mins. to 4 hrs. 42 mins.
,, ,, concrete protection .	1 hr. 47 mins. to 8 hrs. 24 mins.

The superiority of concrete as a fire resistant is exemplified not only by the reinforced columns, but also by the protected columns where concrete gives better results than other protecting materials. The paper in question gives many tests of other columns such as timber, unprotected steel, cast iron, etc., and the results confirm the wisdom of placing such constructional materials in an entirely different class from concrete and protected steel.

A further and most valuable piece of evidence upon the subject is given by the British Fire Prevention Committee's " Red Book " No. 207, showing the results of the investigation following the fire at the Edison Phonograph Works at New Jersey, U.S.A., where a number of large reinforced concrete buildings were involved. In this publication, the following extract is given from a report upon the fire by the Associated Factory Mutual Fire Insurance Companies of America—a body which represents the interests of the building owner and quite impartial as to constructional materials :

" This fire shows that a reinforced concrete building is a fairly good furnace or stove, for these buildings withstood the complete burning out of a large amount of combustible contents with only such damage to the buildings themselves as can be repaired at reasonable cost."

The severity of the fire is demonstrated by the fact that fused iron,

copper, brass and glass were found in the concrete buildings after the fire, and it was considered that temperatures in excess of 2,500 deg. F. were reached. The following extracts from the "Red Book" are quoted :

"In general, under ordinary conditions of fire exposure, the concrete, while cracked, was not damaged to any great extent.

"The end walls in the three upper floors . . . were of reinforced concrete 8 in. thick . . . while this was in the hottest part of the fire, these walls were practically undamaged, and are an admirable demonstration of the value of concrete walls as a fire barrier.

"In the greatest portion of these buildings the concrete remained firm and hard and intact after this severe heat treatment.

"While the surface indications were that the strength of the floor construction had been severely damaged by the fire, the factor of safety assumed in the design was sufficient to meet the unusual fire test, and the floors before repairs had sufficient strength to carry, for a time at least, the designed live load, although the use of the building and the effect of moving machinery might have later reduced the strength if repairs had not been made.

"The salvage in machinery in the reinforced concrete buildings is at least 94 per cent. ; of the buildings 87 per cent., and the cost for the restoration of the buildings from 10 to 15 per cent."

CHAPTER 8.

CONCRETE FLOORS.

THE following abstracts are from the "Standard Specifications for Concrete Floors," prepared by the Committee of the American Concrete Institute on Concrete Floor Finish. The specifications apply to floors in buildings, whether subjected to moderate or heavy traffic, and cover the laying and finishing of the floor; also its protection during early hardening.

For those desiring to embody the specifications in their general specifications covering a particular piece of work, the following outline of the paragraphs necessary to meet different conditions is given :—

FLOORS LAID ON GROUND :—MODERATE OR LIGHT TRAFFIC.—
Two-Course—Paragraphs 1–19 (except 8); 34–52; 54–57.
One-Course—Paragraphs 1–19 (except 8); 34–47; 58–62.
FLOORS LAID ON GROUND :—HEAVY TRAFFIC.—
Two-Course—Paragraphs 1–19; 34–51; 53–57.
REINFORCED-CONCRETE FLOORS :—MODERATE OR LIGHT TRAFFIC.—
Paragraphs 1–26 (except 8); 28–33.
REINFORCED-CONCRETE FLOORS :—HEAVY TRAFFIC.—
Paragraphs 1–25; 27–33.

MATERIALS.

1.—The cement shall meet the requirements of the current Standard Specification.

2.—In no case shall aggregate containing frost or lumps of frozen material be used. Crusher-run stone, bank-run gravel, or mixtures of fine and coarse aggregate prepared before delivery on the work shall not be used.

3.—Fine aggregate shall consist of natural sand or screenings from hard, tough, crushed rock or gravel consisting of quartz grains or other hard material, clean and free from any surface film or coating and graded from fine to coarse, with the coarse particles predominating.

4.—Fine aggregate, when dry, shall pass a screen having 4 meshes to the linear in. ; not more than 25 per cent. shall pass a sieve having 50 meshes per linear in. and not more than 5 per cent. shall pass a sieve having 100 meshes per linear in.

5.—Fine aggregate shall not contain injurious vegetable or other organic matter as determined by the colorimetric test nor more than 5 per cent. by volume of clay or loam. If there is more than 7 per cent. of clay or loam by volume in 1 hour's settlement after shaking in 100 per cent. excess of water, the material represented by the sample shall be rejected.

6.—Fine aggregate shall be of such quality that mortar composed of 1 part Portland cement and 3 parts fine aggregate, by weight, when made into briquets, shall show a tensile strength at 7 and 28 days at least equal to the strength of briquets composed of 1 part of the same cement and 3 parts sand, by weight. The percentage of water used in making the briquets of cement and fine aggregate shall be such as to produce a mortar of the same consistency as that of the sand briquets of standard consistency.

7.—Coarse aggregate shall consist of clean, hard, tough, crushed rock or pebbles graded in size, free from vegetable or other organic matter, and shall contain no soft, flat or elongated particles. The size of the coarse aggregate shall range from $1\frac{1}{2}$ in. down, not more than 5 per cent. passing a screen having 4 meshes per linear in. and no intermediate sizes shall be removed.

8.—No. 1 aggregate for the wearing course shall consist of clean, hard, tough, crushed rock or pebbles, free from vegetable or other organic matter, and shall contain no soft, flat or elongated particles. It shall pass when dry a screen having $\frac{3}{8}$ in. openings and not more than 10 per cent. shall pass a screen having 4 meshes per linear in.

9.—Water shall be clean, free from oil, acid, alkali or vegetable matter.

10.—Colouring materials shall be such as will not impair the strength of the concrete.

11.—The reinforcing metal shall meet the requirements of the current standard specifications for steel reinforcement. It shall be free from excessive rust, scale, paint or coatings of any character which will tend to reduce or destroy the bond.

12.—The joint filler shall be a suitable compound that will not become soft and run out in hot weather, nor hard and brittle and chip out in cold weather ; or prepared strips of fibre matrix and bitumen. The strips shall be $\frac{1}{2}$ in. in thickness and their width shall at least equal the full thickness of the slab.

CONSTRUCTION.

13.—The method of measuring the materials for the concrete or mortar, including water, shall be one which will ensure separate and uniform proportions of each of the materials at all times.

14.—All concrete shall be mixed by machine, except under special conditions. The ingredients shall be mixed to the specified consistency, and the mixing shall continue for at least 1 minute after all the materials are in the drum. Raw materials shall not be permitted to enter the drum until all the material of the preceding batch has been discharged.

15.—When it is necessary to mix by hand, the materials shall be mixed dry on a watertight platform until the mixture is of uniform colour, the required amount of water added, and the mixing continued until the mass is of uniform consistency and homogeneous.

16.—Retempering of mortar or concrete which has partially hardened (that is, mixing with or without additional materials or water) shall not be permitted.

17.—As soon as the finished floor has hardened sufficiently to prevent damage thereby, the floor shall be covered with at least 1 in. of wet sand, or 2 in. of sawdust, which shall be kept wet by sprinkling with water for at least 10 days.

18.—The freshly-finished floor shall be protected from hot sun and drying winds until it can be sprinkled and covered as above specified. The concrete surface must not be damaged or pitted by raindrops, and the contractor shall provide and use when necessary sufficient tarpaulins to completely cover all sections that have been placed within the preceding 12 hours.

19.—If at any time during the progress of the work the temperature is, or in the opinion of the architect or engineer will, within 24 hours, drop to 40 deg. Fahr., the water and aggregates shall be heated and precautions taken to protect the work from freezing for at least 5 days.

REINFORCED-CONCRETE FLOORS.

For reinforced-concrete floors the following will apply in addition to paragraphs 1 to 19 inclusive.

20.—*Forms.*—The forms shall be substantial, unyielding, and so constructed that the concrete will conform to the designed dimensions and contours, and shall also be tight to prevent the leakage of mortar. The supports for floors shall not be removed without the consent of the engineer in charge. Permanent shores shall be placed in such a manner as to assure safety of the floors after temporary supports are removed.

21.—*Reinforcement.*—Reinforcing metal shall be mechanically held in position so that it will not become disarranged during the depositing of the concrete. Whenever it is necessary to splice tension reinforcement, the character of the splice shall be such as will develop its full strength. Splices at points of maximum stress shall be avoided. Splicing by lapping bars without contact and with space between bars along the overlap equal to twice the thickness of the bars is preferable to mechanical splices or clamps.

22.—*Concrete Slab.*—The concrete shall be mixed in the proportions by volume of 1 cu. ft. of Portland cement, 2 cu. ft. of fine aggregate, and 4 cu. ft. of coarse aggregate.

23.—Only sufficient water shall be used to produce a workable plastic mix, which will flow sluggishly into the forms and around the reinforcement and which can be conveyed from the mixer to the forms without the separation of the coarse aggregate from the mortar.

24.—The concrete shall be placed in a manner to ensure a smooth ceiling, and thoroughly worked around the reinforcement and into the recesses of the forms. Concrete shall be deposited in its final position as soon as possible after mixing. It shall be struck off to a surface at least 1 in. below the established grade of the finished surface of the floor. Workmen shall not be permitted to walk on freshly-laid concrete, and if sand or dust collects on the base it shall be carefully removed before the wearing course is applied.

25.—When it is necessary to make a joint in a floor-slab, its location shall be designated by the architect or engineer; joints to be vertical.

WEARING COURSE.

26.—(Mixture No. 1.)—The mortar shall be mixed in the proportions of 1 cu. ft. of Portland cement and 2 cu. ft. of fine aggregate. The minimum thickness shall be $\frac{3}{4}$ in.

27.—(Mixture No. 2.)—The mortar shall be mixed in the proportions of 1 cu. ft. of Portland cement, 1 cu. ft. of fine aggregate, and 1 cu. ft. of No. 1 aggregate for wearing course. The minimum thickness shall be $\frac{3}{4}$ in.

28.—The mortar shall be of the driest consistency possible to work with a sawing motion of the strikeboard.

29.—The wearing course shall be placed immediately after mixing. It shall be deposited on the fresh concrete of the base before the latter has appreciably hardened, and brought to the established grade with a strikeboard.

Note.—When placing the wearing course after the concrete slab

has hardened, eliminate paragraph 29 and substitute paragraphs 30 and 31.

30.—The surface of the slab shall be thoroughly roughened by picking or other means and cleaned of all dirt and débris.

31.—The slab shall be thoroughly moist but free from pools of water when the grout and mortar for wearing course is placed. A neat cement grout shall be brushed on the surface of the slab, the wearing course immediately applied and brought to the established grade with a strikeboard. Grout and mortar shall be used within 45 minutes after mixing with water.

32.—After the wearing course has been brought to the established grade by means of a strikeboard, it shall be worked with a wood float in a manner which will thoroughly compact it and provide a surface free from depressions or irregularities of any kind. When required, the surface shall be steel-troweled, but excessive working shall be avoided. A mixture of dry cement, sand and No. 1 aggregate may be applied to the fresh concrete of the base for a wearing course, but in no case shall dry cement or a mixture of dry cement and sand be sprinkled on the surface of the wearing course to absorb moisture or to hasten the hardening.

33.—If artificial colouring is used, it must be incorporated with the entire wearing course and shall be mixed dry with the cement and aggregate until the mixture is of uniform colour. In no case shall the amount of colouring exceed 5 per cent. of the weight of the cement.

PLAIN CONCRETE FLOORS.

For plain concrete floors the following will apply in addition to paragraphs 1 to 29 inclusive.

34.—*Subgrade.*—All soft and spongy places shall be removed and all depressions filled with suitable material which shall be thoroughly compacted in layers not exceeding 6 in. in thickness. The subgrade shall be thoroughly tamped until it is brought to a firm, unyielding surface.

35.—All fills shall be made in a manner satisfactory to the architect or engineer. The use of muck, quicksand, soft clay, spongy or perishable material is prohibited.

36.—When required, a suitable drainage system shall be installed and connected with sewers or other drains indicated by the engineer.

37.—The subgrade shall not be less than —— in. below the finished surface of the floor.

Note.—Subgrade is to be —— in. below the finished surface of the

floor when subbase is not required, and at least —— in. below when subbase is required.

38.—*Subbase.*—Only clean, hard material, such as coarse gravel or cinders free from ash or particles of unburned coal, shall be used in the subbase.

39.—The material shall be spread on the subgrade, thoroughly rolled or tamped to a surface at least —— in. below the finished grade of the floor. On fills, the subbase shall extend the full width of the fill.

40.—While compacting the subbase, the material shall be kept thoroughly wet, and shall be in that condition when the concrete is deposited.

Note.—Omit these sections when subbase is not required.

41.—*Forms.*—Forms shall be free from warp and of sufficient strength to resist springing out of shape.

42.—The forms shall be well staked or otherwise held to the established lines and grades, and their upper edges shall conform to the established grade of the floor.

43.—All wood forms shall be thoroughly wetted and metal forms oiled or coated with soft soap or whitewash before depositing any material against them. All mortar and dirt shall be removed from the forms that have been previously used.

44.—*Limiting Conditions.*—The slabs or independently-divided blocks when not reinforced shall have an area of not more than 100 sq. ft., and shall not have dimensions greater than 10 ft. Larger slabs shall be reinforced as hereinafter provided.

45.—The thickness of the floor shall be not less than —— in.

46.—When required by the architect or engineer in charge, a $\frac{1}{2}$-in. space or joint shall be left between the floor and the walls and columns of the building, to be filled with the material specified under "Joint Filler."

47.—Where required, the edges of the slabs at the joints shall be protected by metal. Unless protected by metal, the upper edges of the slabs shall be rounded to a radius of $\frac{1}{2}$ in.

TWO-COURSE PLAIN CONCRETE FLOOR.

48.—*Concrete Base.*—The concrete shall be mixed in the proportions by volume of 1 cu. ft. of Portland cement, $2\frac{1}{2}$ cu. ft. of fine aggregate, and 5 cu. ft. of coarse aggregate.

49.—The materials shall be mixed wet enough to produce a concrete of a consistency that will flush readily under slight tamping, but which

can be handled without causing a separation of the coarse aggregate from the mortar.

50.—After mixing, the concrete shall be handled rapidly and the successive batches deposited in a continuous operation completing individual sections of the required depth and width. Under no circumstances shall concrete that has partly hardened be used. The forms shall be filled and the concrete struck off and tamped to a surface the thickness of the wearing course below the established elevation of the floor. The method of placing the various sections shall be such as to produce a straight, clean-cut joint between them so as to make each section an independent unit. If dirt, sand, or dust collects on the base, it shall be removed before the wearing course is applied. Any concrete in excess of that needed to complete a section at the stopping of work shall not be used. In no case shall concrete be deposited upon a frozen subgrade or subbase.

51.—Slabs having an area of more than 100 sq. ft. shall be reinforced with wire fabric, or with plain or deformed bars. The reinforcement shall have a weight of not less than 28 lb. per 100 sq. ft. The reinforcement shall be placed upon and slightly pressed in the concrete base immediately after the base is placed. It shall not cross joints and shall be lapped sufficiently to develop the full strength of the metal.

52.—*Wearing Course.*—The wearing course shall be mixed in the proportions of 1 cu. ft. of Portland cement to 2 cu. ft. of fine aggregate. The minimum thickness shall be $\frac{3}{4}$ in. Or

53.—The wearing course shall be mixed in the proportions of 1 cu. ft. of Portland cement, 1 cu. ft. of fine aggregate, and 1 cu. ft. of No. 1 aggregate for wearing course. The minimum thickness shall be $\frac{3}{4}$ in.

54.—The mortar shall be of the driest consistency possible to work with a sawing motion of the strikeboard.

55.—The wearing course shall be placed immediately after mixing. It shall be deposited on the fresh concrete of the base before the latter has appreciably hardened, and brought to the established grade with a strikeboard. In no case shall more than 45 minutes elapse between the time the concrete for the base is mixed and the wearing course is placed.

56 and 57.—As paragraphs 32 and 33.

ONE-COURSE FLOOR.

58.—The concrete shall be mixed in the proportions of 1 cu. ft. of Portland cement to not more than 2 cu. ft. of fine aggregate and not more than 3 cu. ft. of coarse aggregate, and in no case shall the volume

of the fine aggregate be less than $\frac{1}{2}$ the volume of the coarse aggregate. A cu. yd. of concrete in place shall contain not less than 6·8 cu. ft. of cement.

59.—The materials shall be mixed with sufficient water to produce a concrete which will hold its shape when struck off with a strikeboard. The consistency shall not be such as to cause a separation of the mortar from the coarse aggregate in handling.

60 and 61.—As paragraphs 50 and 51.

62.—After the concrete has been brought to the established grade by means of a strikeboard, and has hardened somewhat, but is still workable, it shall be floated with a wood float in a manner which will thoroughly compact it and provide an even surface. When required, the surface shall be steel troweled, but excessive working shall be avoided. Unless protected by metal, the surface edges of all slabs shall be rounded $\frac{1}{2}$ in.

TYPICAL CONCRETE FLOOR DESIGNS.

The drawings and tables on pages 75, 76 and 77 are given by courtesy of the American Portland Cement Association. They are based on an interior floor panel 20 ft. sq. designed for a live load of 100 lb. and average partition load of 25 lb. per sq. ft.

Unit Stresses.—In computing the sizes of the various types of floors the following allowable unit stresses in lb. per sq. in. were used :

Extreme compressive fibre stress concrete bending .	700
Extreme fibre stress structural steel bending . .	16,000
Tensile stress in reinforcing steel	18,000
Diagonal tension or shear, plain concrete . .	40
Diagonal tension or shear in concrete with proper shear reinforcement.	133

The floor finish, assumed as not heavier than a 2-in. terrazzo finish, is a constant quantity for each type, and has therefore been omitted in the table of quantities, but has been considered in determining the dimension of each floor type.

Computation of Quantities of Materials.—The following example of computing quantities of materials required for a certain type of floor is given.

Required : the quantity of Portland cement and aggregates to be used in a reinforced-concrete flat slab floor 20 ft. by 25 ft. in area and 7 in. thick with a mortar topping $\frac{3}{4}$ in. thick. The concrete in the floor is designed for an ultimate compressive strength of 3,000 lb. per sq. in. at an age of 28 days. Fine aggregate is to be well graded from a

o to No. 4 screen and coarse aggregate well graded from a No. 4 to 1 in. screen. The quantity of water used in mixing should be the least that will produce a plastic and workable mixture ; for floors this consistency would correspond to a slump of from 3 to 4 in.

Referring to Table 1, for the slab having concrete of the above requirements, a mix of 1 : 1·4 : 2·5 is shown. The net quantities of materials required for the concrete in the slab proper, which is 20 ft. by 25 ft., or 500 sq. ft., will be as follows :

$$\text{Portland cement (cu. ft.)} \quad \frac{500}{100} \times 7 \times 2{\cdot}22 = 77{\cdot}70$$

$$\text{Fine aggregate (cu. ft.)} \quad \frac{500}{100} \times 7 \times 3{\cdot}08 = 107{\cdot}80$$

$$\text{Coarse aggregate (cu. ft.)} \quad \frac{500}{100} \times 7 \times 5{\cdot}50 = 192{\cdot}50$$

The net quantities of materials required for the mortar (1 : 1·9 mix) in the topping will be as follows :

$$\text{Portland cement (cu. ft.)} \quad \frac{500}{100} \times \tfrac{3}{4} \times 3{\cdot}32 = 12{\cdot}45$$

$$\text{Fine aggregate (cu. ft.)} \quad \frac{500}{100} \times \tfrac{3}{4} \times 6{\cdot}35 = 23{\cdot}81$$

The total net quantities of materials required in the entire slab with its topping will be the sum of the above like quantities.

Note.—The above quantities are net, and do not allow for waste. For average conditions of waste add 2 per cent. cement, 10 per cent. fine aggregate and 5 per cent. coarse aggregate.

The table also gives quantities of materials in concrete having a still more workable consistency as measured by a slump of 6 to 7 inches.

Method of Using the Table of Quantities.—The total cost of any of these types of floors may be determined by applying the local combined unit labour and material costs to the quantities of material shown in Table 2.

The dead loads of any type of floor may be determined from Table 2. The effect on the columns of the differences in the dead loads of the above floor types when combined with the live loads and average partition loads is negligible.

NET QUANTITIES OF MATERIALS REQUIRED FOR 100 SQ. FT. OF CONCRETE FLOOR, PER 1 INCH OF THICKNESS.

TO OBTAIN THE QUANTITIES OF MATERIALS FOR 100 SQ. FT. OF ANY THICKNESS MULTIPLY VALUES IN TABLE BY THICKNESS IN INCHES.

COMPRESSIVE STRENGTH AT 28 DAYS (LB. PER SQ. IN.)	SLUMP AS A MEASURE OF CONSISTENCY (INCHES)	GRADING OF AGGREGATES ALL FINE AGGREGATE O TO #4 COARSE	PROPORTIONS (FROM ABRAMS TABLES) CEMENT	FINE AGGREGATE	COARSE AGGREGATE	NET MATERIALS FOR 100 SQ. FT. FLOOR PER 1 INCH OF THICKNESS OR FOR 0.308 CU. YD. CEMENT (BAGS OF 94 LBS.)	AGGREGATES (CUBIC FEET) FINE	COARSE
2000	3 TO 4	No 4 to 3/4"	1	2.6	2.8	1.67	4.25	4.67
		" " 1"	1	2.4	3.5	1.54	3.67	5.34
		" " 1 1/2"	1	2.4	4.0	1.45	3.50	5.75
	6 TO 7	" " 3/4"	1	1.9	2.3	1.97	3.75	4.50
		" " 1"	1	1.8	2.9	1.88	3.33	5.40
		" " 1 1/2"	1	1.7	3.4	1.79	3.00	6.00
2500	3 TO 4	" " 3/4"	1	2.0	2.4	1.95	3.83	4.66
		" " 1"	1	1.9	3.0	1.82	3.42	5.40
		" " 1 1/2"	1	1.8	3.5	1.73	3.08	6.00
	6 TO 7	" " 3/4"	1	1.5	2.0	2.34	3.50	4.66
		" " 1"	1	1.3	2.4	2.25	2.92	5.40
		" " 1 1/2"	1	1.3	2.8	2.13	2.75	6.00
3000	3 TO 4	" " 3/4"	1	1.6	2.0	2.31	3.67	4.58
		" " 1"	1	1.4	2.5	2.22	3.08	5.50
		" " 1 1/2"	1	1.4	2.9	2.10	2.92	6.00
	6 TO 7	" " 3/4"	1	1.1	1.6	2.93	3.25	4.66
		" " 1"	1	0.9	1.9	2.81	2.50	5.34
		" " 1 1/2"	1	0.9	2.2	2.66	2.42	5.83
3500	3 TO 4	" " 3/4"	1	1.2	1.7	2.78	3.33	4.75
		" " 1"	1	1.1	2.1	2.65	2.92	5.58
		" " 1 1/2"	1	1.0	2.4	2.44	2.42	5.83
	6 TO 7	" " 3/4"	1	0.8	1.3	3.55	2.83	4.66
		" " 1"	1	0.6	1.5	3.39	2.00	5.07
		" " 1 1/2"	1	0.6	1.7	3.18	1.92	5.40
4000	3 TO 4	" " 3/4"	1	0.9	1.4	3.27	2.92	4.58
		" " 1"	1	0.8	1.7	3.17	2.50	5.34
		" " 1 1/2"	1	0.7	1.9	3.02	2.08	5.66
	6 TO 7	" " 3/4"	1	0.5	0.9	4.38	2.17	4.00
		" " 1"	1	0.4	1.1	4.25	1.67	4.66
		" " 1 1/2"	1	0.4	1.2	4.13	1.67	4.91
TOPPING	1/2 TO 1"	" " 3/8"	1	0.8	1.7	3.08	2.46	5.25
"	" "	——	1	1.9	——	3.32	6.35	——

TABLE I.

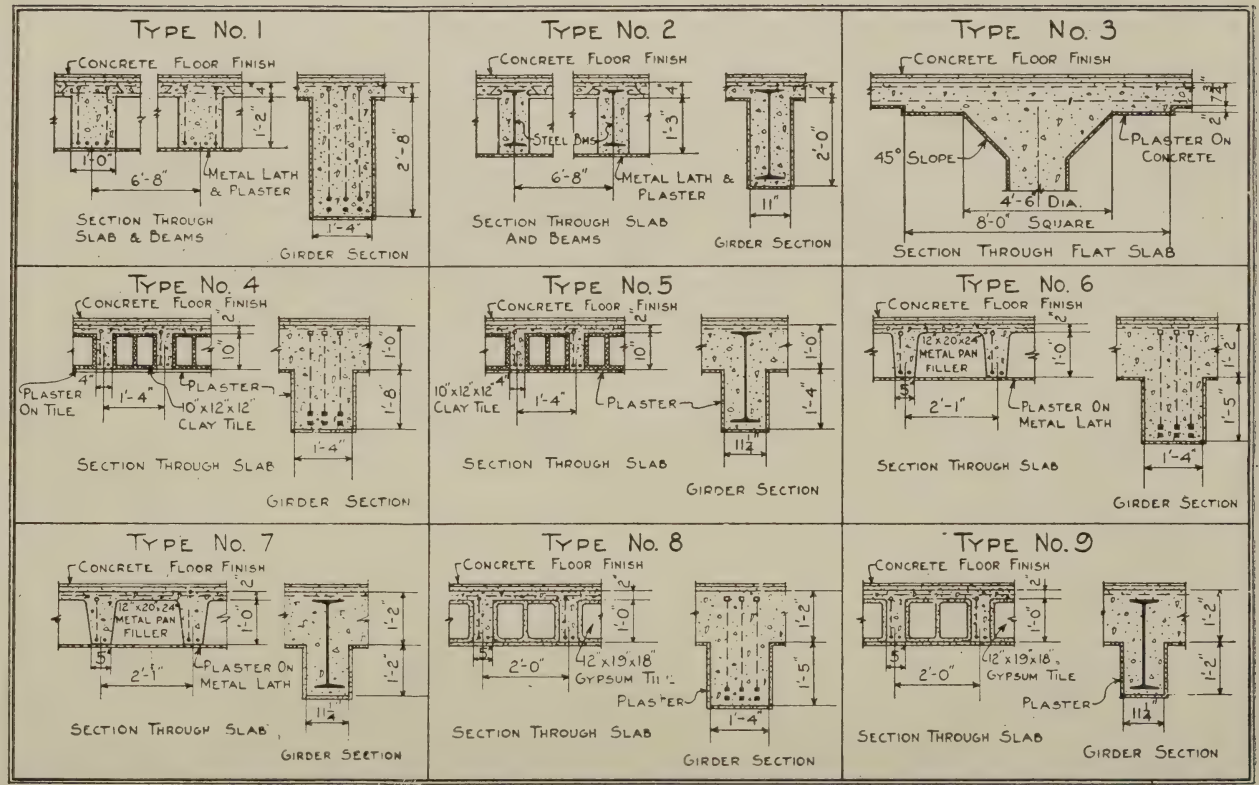


FIG. 14.—TYPICAL CONCRETE FLOOR DESIGNS.

QUANTITIES IN TYPICAL CONCRETE FLOORS — TYPE OF FLOOR	Type Number	Quantities of Materials Per 100 Sq. Ft. in Various Types of Concrete Floors—Girders Included: Quantity Lb. Struct. Steel—Includes Conn. Angles	Quantity Lb. Reinf. Steel—Includes Temp. Bars, etc.	Quantity Cu. Ft. Concrete—Includes Fireproofing	Quantity Sq. Ft. of Forms Contact Surface	Quantity Cu. Ft. 10" x12"x12" Hollow Clay Tile.	Quantity Lin. Ft. 12"x20"x24" Metal Floor Pan Fillers	Quantity Lin. Ft. 12"x19"x18" Gypsum Tile Fillers	Quantity Sq. Yds. Plaster on Tile, Gypsum or Conc.	Quantity Sq. Yds. Plaster on Metal Lath	Total D. L. of Floor Lb. Per Sq. Ft.—Floor Finish Omitted	Ratio of D. L. of Floor to That of Type No. 2	Type Number
Reinf. Conc. Slab, Beams and Girders	1	.....	478.	67.	160.	....	....	....	2.4	10.4	112.	1.11	1
Reinf. Conc. Slab, Steel Beams and Girders	2	1107.	123.	54.	155.	....	....	....	1.3	10.6	101.	1.00	2
Reinf. Conc. Flat Slab—Drop Panel	3	.....	260.	69.	102.	....	....	....	11.2	....	108.	1.07	3
Reinf. Conc. Joists and Girders—Tile Fillers	4	.....	480.	55.	116.	68.	....	....	13.0	....	116.	1.15	4
Type 4 except with Steel Girders	5	450.	330.	50.	113.	68.	....	....	12.5	....	112.	1.11	5
Reinf. Conc. Joists and Girders, Metal Fillers	6	.....	440.	65.	115.	....	42.	....	3.0	10.0	107.	1.06	6
Type 6 except with Steel Girders	7	448.	322.	60.	112.	....	42.	....	2.2	10.0	104.	1.03	7
Reinf. Conc. Joists and Girders, Gypsum Fillers	8	.....	430.	57.	115.	....	....	45.	12.6	....	111.	1.10	8
Type 8 except with Steel Girders	9	450.	330.	52.	112.	....	....	45.	12.4	....	108.	1.07	9

TABLE 2.

CHAPTER 9.

CONCRETE ROADS.

The remarkable increase in popularity of the all-concrete road in this country is shown by the fact that although previous to 1912 there were in the United Kingdom no concrete roads as we understand them to-day, at the end of 1923 some 300 had been built. Like all other types of road, the development of the all-concrete road was greatly hampered, if not stopped altogether, by the war conditions between 1914 and 1918. At the outbreak of war not more than three or four roads of this type had been laid, and at the time of the Armistice that number had only increased to less than twenty. When the restrictions on road construction were removed, however, the number which had been laid during six years was doubled in a few months, and in the four years 1919–23 the number laid during the previous six years increased by 1000 per cent. These figures are a striking indication of the value Borough Surveyors and others now attach to concrete roads.

A complete account of all the concrete roads laid in this country, with detailed particulars of the methods of construction, and latest reports as to their condition, is contained in *Concrete Roads* (Second Edition), obtainable from Concrete Publications, Ltd., 4, Catherine St., Aldwych, W.C.2, price 5*s*. 6*d*. post free. We are indebted to this volume for some of the matter in this chapter.

In connection with the use of concrete for road covering there seems to have arisen an atmosphere of suspicion and even mystery, for which it is somewhat difficult to account. The application of concrete to all other types of constructional work is regarded largely as a matter of calculation to decide the required dimensions. But with concrete roads the impression appears to be abroad that there are other rules which govern the subject and that the conditions for success are to some extent unknown and different from those operating in ordinary concrete work. To what extent this impression is well founded may perhaps be determined by considering the conditions a concrete road is required to withstand.

It is desirable that a concrete road surface should have three qualities, namely (1) strength to bear the loads it has to carry without fracture, (2) resistance to the wear arising from wheeled and horse traffic, and (3) freedom from cracking.

With regard to the first-mentioned quality of strength, it is obvious that this is a matter of design which presents no difficulty to the concrete designer. There have indeed been so many concrete road *beds* successfully laid down that the design so far as strength is concerned may almost be said to be stereotyped, although in this case the question of resistance to wear has not arisen. If road surveyors believed that the success of a concrete road depended solely on strength there would probably be very little hesitation in adopting concrete roads.

The next quality is resistance to wear, and this is probably the stumbling-block to those without experience. It may in fact be admitted that this is the most critical condition upon which concrete roads must stand or fall. The hesitation in accepting concrete as a wear-resistant was perhaps natural in the absence of any generally-accepted data upon the subject, and even now, when it cannot be denied that there are many successful concrete roads in existence, the hesitation may still linger because the conditions which lead to success are not clearly defined. In effect, the road engineer requires to know what is necessary to make concrete wear-resisting. For the evidence on this point we have to thank the investigators at the Structural Materials Research Laboratory at Chicago, who set out to determine experimentally the conditions which make concrete wear-resisting. The conclusion to be drawn from their exhaustive investigation can be expressed in the one word "quality." The most wear-resisting concrete is that with the highest quality as expressed in compressive strength, from which it follows that a satisfactory concrete road surface demands a strong concrete.

The conditions that produce a strong and therefore wear-resisting concrete are well known, and may be summarised as a high proportion of cement, no excess of water beyond that required to produce a plastic concrete, thorough mixing, graded clean aggregate, proper curing (i.e., keeping the concrete damp during the period of early hardening), and age. A further assurance of success can be obtained by applying to the surface of the road a non-proprietary surface hardener, such as sodium silicate solution. Such treatment also has the advantage of accelerating the hardening of the concrete and so reducing the period during which traffic must be excluded from the road. The American investigations have thus dispelled the atmosphere of mystery that has

surrounded concrete road construction, and have brought this branch of engineering practice within the region of common sense again.

The third quality needed in a concrete road is freedom from cracking, which results from the fact that as concrete must be mixed with more water than the cement can absorb contraction is bound to occur when the excess water evaporates. The tendency to crack that follows on contraction can be mitigated by preventing evaporation (by keeping the concrete damp) for a fortnight or more until the concrete is strong enough to resist the stresses that occur with contraction. Restriction of water for concrete mixing to the minimum required for plasticity is, of course, also of great importance in this connection. Further assistance may be given by reinforcement, such as steel mesh, as near the surface as is compatible with protection from corrosion. In properly made concrete roads cracks are the exception rather than the rule, and where they do occur they are generally so small that a pen-knife cannot be inserted in them. Such cracks are comparatively harmless if filled up with pitch or similar semi-plastic material, and the annual renewal of this filling, at the cost of a few pounds per mile, constitutes the only repair charge of a good concrete road. Under certain conditions, however, it is possible to avoid the irregular cracks by dividing up the road into lengths separated by plastic jointing material, making in effect an artificial transverse crack in the concrete surface at regular intervals (say, 50 ft.), which does away with the suggestion of any unsightliness associated with irregular cracks which might form naturally.

Regarded from a common-sense standpoint, then, the secret of success with concrete roads is to employ strong concrete ; every precaution that can be taken to ensure good concrete will justify itself in the life of the road. Unless a road surveyor can rely upon producing a strong concrete he would be well advised to choose some other material for his road surface. Money spent upon obtaining a strong concrete road surface will avoid the initial and recurring expenditure of applying tar or other bitumastic covering, and will prove an excellent investment.

COST.

The cost of a concrete road varies, of course, according to the nature of the site, cost of materials, rates of wages, etc., in different localities, but from the following figures, relating to a recently laid road in a rural area, it should be possible to estimate the approximate cost in any district by making allowances for differences in the price of materials and wages, and increasing or decreasing the sum for excavating and grading according to the condition of the site :—

	Cost of road per 6 in. thick. per yd. super	
	s. *d.*	*s.* *d.*
Excavating and grading *	1 6	
Rolling sub-base to camber	0 3	
		1 9
Aggregate (sand and ballast) at mixer, at 12*s.* per cu. yd. .	2 0	
Cement (1 : 5 mix), at 70*s.* per ton	2 9	
Labour : Mixing, screeding and finishing, at 1*s.* per hour .	1 3	
Supplying and fixing forms, etc.	0 4	
Watering, watching, and curing	0 6	
		6 10
Total		8 7

* If laid on an existing road, this item would be reduced to 6*d.*, or even less Where reinforcement is used, this would cost about 1*s.* 6*d.* per yard super laid,

THE CONSTRUCTION OF A CONCRETE ROAD.

So much depends on the nature of the soil and the traffic to be carried that it is impossible to lay down any hard and fast method for the construction of an all-concrete road. The following notes, however, give the general practice now followed in this country :—

Materials.—The cement is such an important factor that it is essential that it should comply with the requirements of the British Standard Specification, and should be slow-setting cement.

Care should be taken in the selection of the aggregates. No natural deposits of sand and gravel should be used without washing, screening, and grading. If crushed stone is used it should be screened, graded, and, if necessary, washed. No aggregate should be used which is not hard and tough, or which is laminated, and upon crushing breaks down into flat or elongated particles. Soft or porous materials, such as broken brick, breeze, etc., should be prohibited. All aggregates used must be clean and free from clay, dust, vegetable and other foreign matter. Care must be taken that the aggregate is not contaminated with mud, etc., after delivery to the site of the work.

For one-course roads no aggregate should be used which will not pass through a screen having square openings of 1 in., but for two-course roads the bottom course may contain aggregate the largest stones in which will pass through a 1½-in. square opening. None of the coarse material should pass through a ¼-in. square opening. The grading from the maximum to the minimum sizes should be regular, and no material should be used which contains a large proportion of stones of approximately one size. Chippings for the upper course of a two-course road should be graded from ½ in. to ¼ in.

Sand or fine material should pass through a ¼-in. square opening, but not more than 10 per cent. by weight should pass a sieve having 50 meshes per lin. in. The grading from the maximum to the minimum sizes should be regular, and no material should be used which contains a large proportion of particles of approximately one size.

The average crushing strength of the concrete should be about 3,000 lb. per sq. in. at 28 days.

For determining the compression resistance, tests should be made on cubes or cylinders of not less than 6 in. each way which as far as possible conform to the conditions that will obtain in the actual execution of the work.

The water must be fresh and clean.

Joint filler, if used, must be a fibrous, elastic waterproof material, which will not lose these properties under extremes of weather conditions.

Preparation of Subsoil.—The preparation of the foundation will necessarily vary with local conditions. Any necessary embankments or fills should be thoroughly consolidated, so that there is no possibility of settlement at any point. Any soft or weak places must be excavated and filled with hard stone or other suitable material, so as to obtain solidity equal to the remainder of the surface. The surface should be finally rolled to the required contour with a roller of not less than 10 tons in weight. The surface thus prepared must be regular, either flat or with a slight cross fall. Immediately before the concrete is placed, all foreign matter must be removed from the prepared surface, which must then be thoroughly watered.

Concrete.—For one-course roads 1 part cement, 2 fine aggregate and 4 coarse material appears to give the best results. For the lower course in two-course roads the volume of coarse and fine aggregate when mixed should not exceed 6 to 1 of the volume of the cement. The proportion of 1 : 2½ : 5 has given satisfaction. For the top course a mixture not weaker than 1 : 1½ : 3 (chippings) is recommended.

The concrete should preferably be mixed in a batch mixer, and mixing must continue until the ingredients are homogeneous and plastic throughout. The drum must be completely emptied after mixing each batch. The quantity of water should be such as to secure a plastic mixture. The slump test (see p. 22) is recommended to secure a consistent mix. The maximum slump desirable is 1 in. This will prevent an excessive amount of water being used, and the concrete will not be so sloppy as to cause a separation of the coarse aggregate from the mortar during handling and laying. Any concrete which has partially set before being placed in position should not be used.

So far as is practicable, all work should be done between temperatures of 35 deg. and 75 deg. F., but in the event of concrete roads having to be laid when the thermometer is below 35 deg. F., care should be taken that all materials used are free from frost, and the completed work must be protected from freezing. It is essential that the concrete be protected against the sun's rays, especially when working in temperatures above 65 deg. F.; it should also be protected from drying wind, irrespective of temperature. Serious cracking is possible if this precaution is not taken.

When night frosts are prevalent a sufficient quantity of material should be protected to enable the next day's work to start promptly.

The concrete should be deposited over the whole width of the road at one time, except in cases where it is impossible to divert the traffic for the time being. The sides of the road, where there is no kerb, at the end of each day's work, must be supported by a wooden or metal form sufficiently strong and properly supported to resist straining out of shape under the pressure of the concrete. All mortar and dirt must be removed from forms which have been previously used, and the forms greased or oiled before any concrete is deposited against them. The side forms should remain in place until the concrete is set sufficiently hard to permit of the removal of the forms without damage to the edges. In removing the form at the end of the previous day's work, in order to resume operations the next day, special care must be taken to ensure that the concrete is not damaged, and in beginning the deposition of concrete special care must be taken with the tamping of the concrete to ensure that the previous day's work is not disturbed or damaged in any way. If desired, joints filled with a filler may be provided between each day's work, but should not exceed $\frac{1}{4}$ in. in thickness. The filler should protrude $\frac{1}{4}$ in. above the surface of the road, and before the traffic is put on it should be flattened down.

It is advisable to introduce expansion joints in places exposed to extremes of temperature. Longitudinal joints similarly filled may also be provided alongside the kerb or channelling (if any) if desired.

Where no expansion joints are provided the face of the concrete laid the previous day must be chipped back 1 in. and watered. The concrete should then be laid immediately.

In cases where it is impossible to divert the traffic, and the concrete has to be laid on one-half of the road at a time, the edge of the concrete in the centre of the road should be treated as in the case of transverse joints.

Under average conditions, a total thickness of about 6 in. will

probably be sufficient. The surface course of two-course roads should be approximately 2 in. thick. When a two-course road is being laid the upper course or wearing surface must be spread on the lower course immediately after the latter is deposited and before it has begun to set.

Immediately after being placed in position the concrete must be struck off to approximate grade and camber and then thoroughly consolidated to eliminate all voids and surface moisture. This consolidation is effected by tamping the surface of the concrete, either mechanically or by hand, or it may be done by rolling. In no event should any tamping device be used which necessitates a penetration below the concrete surface. A design for a hand-tamper is illustrated in *Fig.* 15. The finished surface should have a cross fall sufficient only to ensure that the surface water will pass off the roadway quickly, and should not vary more than $\frac{1}{4}$ in. from true shape. It will be found that, at the most, a cross fall of 1 in 50 will be sufficient. A simple apparatus for surface finishing, as used by Mr. Arthur Harrison, M.Inst.C.E., Borough Engineer of Southwark, is illustrated in *Fig.* 16.

In cool weather no cessation of work of more than an hour's duration should be permitted, except at the end of a completed day. In hot weather the work must, if possible, be continuous.

The concrete may be reinforced with steel reinforcement at the discretion of the surveyor.

The surface of the concrete should be sprayed with water as soon as it has sufficiently hardened to withstand pitting, and kept wet until covered, within 24 hours, with clay, earth, or other material, which must be kept thoroughly wetted for a period of at least 10 days. When sunshine, a drying wind, or other conditions make it desirable, the freshly laid concrete should be protected by canvas laid on a wooden framing or other covering until set sufficiently to be watered and protected as prescribed.

The road should not be opened to traffic until at least 21 days after it is laid, and when the weather is cool or wet this period should be increased. Where the road is constructed in two halves the traffic should not be concentrated on to the first half which has been concreted until at least 35 days after completion, or longer where weather conditions make it desirable.

CONCRETE ROAD CONSTRUCTION ON MARSHY GROUND.

In cases where concrete roads are to be built on marshy ground, the actual roadway should be of light construction, and it is essential

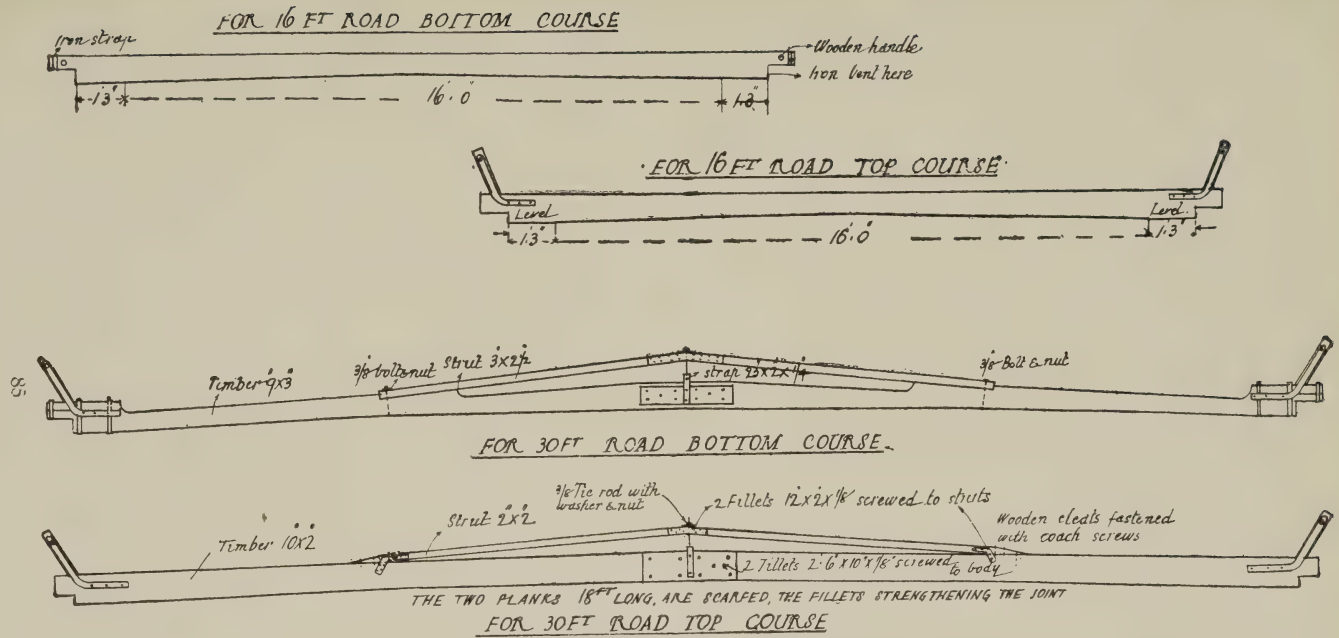


FIG. 15.—A HAND-TAMPER FOR CONCRETE ROADS.

The tamper has a shoe of wrought iron, 2½ in. wide and ⅛ in. thick, screwed on, the ends being turned upwards. A clearance of 6 in. to 3 in. on each end of the tamper should be a minimum to lap over the side forms. The timber for 16-ft. roads, or roads narrower than 16 ft., should be about 2 in. by 3 in. The handles should be close to the end of the tamper, as shown.

to have the reinforcement at the bottom ; reinforcement is also sometimes put near the top to resist contraflection.

Ditches should be filled in with hard-core or dirty ballast to a depth of about 2 ft. and rolled with a six-ton roller, or a heavier roller if the surrounding surface will stand it. The object is to get the same strength

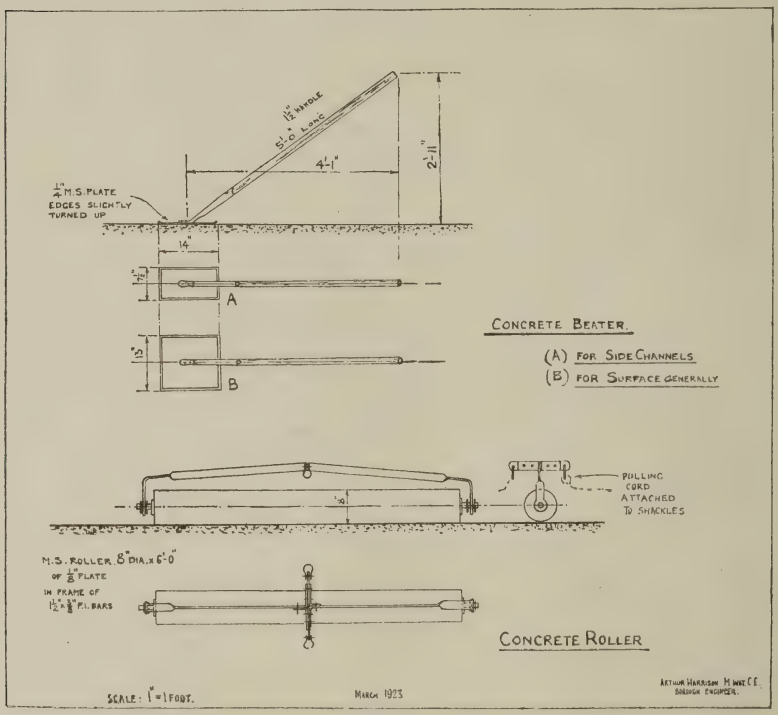


FIG. 16.—APPARATUS FOR SURFACE FINISHING AS USED FOR REINFORCED CONCRETE ROADS AT SOUTHWARK.

of surface all over ; it is not necessary to make the ditch fill stronger than the natural ground. About 3 in. of ashes should be spread all over the hard-core and natural service and rolled in. Rolling in wet weather should be avoided, as the ashes get rolled into the alluvial deposit or mud and wasted. In addition, the ashes make a clean base for the men to work on. The ashes must be thoroughly burned, as it cannot be guaranteed that none of them will get into the concrete during the

construction of the road—if unburnt ashes escape into the concrete, " blow holes " will occur.

When concreting, the layer of ashes must be sufficiently damped just in front of the concreting to prevent the cement slurry from soaking through, as this would result in the appearance of " worm holes " in the finished concrete work.

If a tamping screed is used on flat ground, great care must be taken that the side forms are set firm, and particular attention paid that there are pegs close to the joints supporting the forms.

The drains to gulleys across the road should be laid well ahead, and ballast filled on top. It is advisable to place an extra layer of reinforcement at 2 in. from the top of the concrete extending about 1 ft. or 1 ft. 6 in. over each side of the trench.

Crossings must be left for future house drains, gas mains, cables, etc. These can be filled in temporarily with a row of granite setts, hard-core, or concrete, which will also act as useful breathers for the road during the initial setting. An extra top reinforcement should be placed in the last 18 in. of a day's work, leaving another 18 in. bare to which the next day's work will knit. The scum pushed to the end of the previous day's work should be cut away to a depth of about 1 in. vertically through a thickness of at least 4 in. before starting the next day's work ; this should be done the next day, even if the work has to be left several days, as it is much more expensive later if the concrete is as good as it should be.

Maximum and minimum temperatures should be taken each day, and it should be remembered that the British Standard tests are generally at about 60 deg. F., whereas the work may be taking place at a temperature of 36 deg. or 80 deg., and that the setting-time is lengthened or shortened according to whether the temperature be low or high.

In hot weather the work must not be stopped for meals. Gangs should be halved through the dinner-hour, and if a two-course road is being built the lower and upper courses must be placed on one another as quickly as possible ; the belt, if used, must also follow very close. It is absolutely essential to keep the concrete moist during its initial set, and everything possible should be done to delay the set ; if it is allowed to set quickly cracks are bound to appear. The midday sun is a very tricky problem, and must be guarded against.

In cool weather half an hour for dinner may be taken by the whole gang, and the top course need not follow quite so closely. A covering of ballast is very desirable, as it retains the moisture from rain and only needs rare watering. In summer it is best to lay " Textilose " (a close-

knit canvas) or similar covering direct on the concrete immediately it is free of the belt, but the covering must be kept wet. On removing the covering the road will look patchy, but that appearance is given by the cement slurry, which traffic quickly removes; granite chippings do not adhere to it, nor is it in any way disturbed by the use of this material. Next day the covering should be removed and the concrete covered with ballast saturated with water.

In a two-course road, both courses should be tamped. The granite chippings must be sharp, very clean, and free from dust. The ballast aggregate for the bottom course must be properly graded and very clean —much cleaner than many so-called "washed" ballasts as supplied. The cement must be very slow setting in summer, but rather quicker in winter in order that the initial set may take place before the night frost appears.

A wooden float should not be used *ad lib.*, as it is liable to undo all the good work already done, unless it is used in a very skilled manner and before the set has taken place.

The mix must be a little wetter in summer than in winter, but never sloppy, and never so wet as the men like it. The wetter it is the easier it is to work up a surface, and less tamping has to be done per square yard. On the other hand, the surface must not be tamped until all the cement has been brought to the surface.

In a thin road, i.e., 6 in. thick, rather more cement is necessary than would be allowed for normal reinforced concrete floors, in order that the tamping may leave sufficient cement in the bottom.

AGGREGATE FOR CONCRETE ROADS.

The size of the aggregate will depend partially on the depth of the concrete. In the case of a one-course road the size should not be larger than will pass through a $1\frac{1}{2}$-in. square mesh; and if the depth is not more than 7 in. the maximum mesh allowed should be 1 in. square.

For a two-course road, the aggregate for the bottom course, if not more than 7 in. thick, should all pass through a $1\frac{1}{2}$-in. square mesh, and a slightly larger mesh may be allowed for a greater thickness. None of the coarse material should pass through a $\frac{1}{4}$-in. square mesh.

In the top course the maximum size of the mesh to be allowed should be $\frac{1}{2}$ in.

The fine aggregate or sand should not include an excessive proportion of fine particles, and preferably should be graded from $\frac{1}{16}$ in. downwards, but not more than 10 per cent. by weight should pass a 50×50 sieve.

If only fine sand is available, a greater proportion of cement must be used, as every particle of sand must have its coating of cement to ensure a good concrete, and many engineers in these circumstances first mix the sand and cement dry, and then add the coarse aggregate in order to obtain the desired result.

Most sea-shore gravels are suitable when screened to their proper sizes.

Pit-ballast generally requires washing, and is then usually suitable.

Limestone is not perfect as a top-course aggregate, as it wears into a rather slippery surface, but it is excellent for the bottom course.

Whinstone makes good concrete ; the dust, however, should not be used, and as the chippings are apt to crush rather flat, care should be taken, in the case of a two-course road, to obtain them from a quarry which produces a very large proportion of cubical chippings.

Granite is good for either one-course or two-course roads, both as coarse aggregate or as chippings, which are generally very cubical.

Some slags make a very good concrete, but care should be taken in selection ; if sulphur is present the slag should be discarded unless the percentage of sulphur is almost negligible.

Sea sand is generally satisfactory, but blown sand, if used, must be carefully tested with cement first, as it will generally be found that a large quantity of the latter is required to make anything like a satisfactory concrete.

HARDENING CONCRETE ROAD SURFACES.

The first essentials in obtaining a wear-resisting surface to a concrete road are good materials and good workmanship, but the surface of concrete may be hardened by applying to it a solution of sodium silicate. This material acts by converting the hydrate of lime that is liberated during the setting of cement into silicate of lime, which has the faculty of hardening. The concrete is only hardened to the extent to which the sodium silicate solution penetrates. Sodium silicate is not a proprietary article, and can be obtained in bulk from any manufacturing chemists. There are, however, several forms, and for hardening concrete the most useful form is that known in the trade as the " 3·3 ratio," which means there are 3·3 molecules of silica present per molecule of soda. This material is generally sold in the form of a concentrated solution, and for application to concrete one gallon of the solution should be mixed with five gallons of water. A convenient way of applying the solution is through the rose of a watering-can, and no more should be put on the concrete than can be absorbed. Three

applications at intervals of twenty-four hours are desirable. Sodium silicate is also known as "water glass," and can be purchased retail under this name. Several of the concrete roads in the borough of Southwark, and elsewhere, are now receiving a surface treatment of silicate of soda.

THE BATES ROAD TEST.

What is undoubtedly the most exhaustive test ever undertaken in order to gain a definite knowledge of the wearing properties of various kinds of road when subjected to modern traffic has been undertaken by the State of Illinois, U.S.A. The test road consisted of over sixty-three sections, each 18 ft. wide and from 100 ft. to 250 ft. in length, laid end to end, so that they made a continuous straight pavement two miles long. Twenty-two of these sections were of brick, seventeen of asphalt, and twenty-four of concrete. In each type of road the section varied from those so thin that they were sure to break under the lighter test loads to sections which were considered strong enough to support successfully the heaviest loads permitted by the United States traffic laws. All the materials used in the different sections conformed to the standards required by the Illinois State specification, which are very high.

Over this road a fleet of army trucks made 23,000 round trips. Beginning with the bare chassis, loads were increased in 2,000-lb. increments until a gross load of $12\frac{1}{4}$ tons was reached. The greatest traffic imposed upon any section was 377,460 tons, of which 52·6 per cent. was the legal limit of 4 tons per rear wheel.

Many of the early failures are what one would naturally expect, but of the thirteen sections which survived the test without failing ten were all-concrete roads. The other three types which did not fail were asphalt on a 7-in. concrete base and 3-in. brick on a $5\frac{1}{2}$-in. concrete base. The concrete roads which failed at a gross load of 14,700 lb. were none of them more than 5 in. thick. Three single-course reinforced all-concrete roads, 5 in., 6 in. and 7 in. thick, failed at a load of 21,900 lb. One reinforced concrete road 5 in. thick and one plain concrete road 5 in. thick, both laid in one course, failed at 28,420 lb.

The sections which survived the test seem to provide some well-defined indications as to the relative merits of the systems in use. For example, of the ten all-concrete sections which survived the test, seven were reinforced. The reinforced sections varied in thickness from 5 in. to 7 in., while the unreinforced sections were 8 in. and 9 in. thick.

A system of circumferential reinforcement was used in all the reinforced sections which survived.

The concrete in all the concrete roads was a 1 : 2 : 3½ mixture.

ROAD ACCESSORIES.

CONCRETE KERBING.

Concrete kerbing is now being extensively adopted in this country, and the following notes on the practice in one or two districts may be of use.

The Aylesbury Corporation (Mr. W. H. Taylor, Borough Engineer) has made concrete kerbs and channelling for the past twelve years. The kerbs are 5 in. by 10 in. by 3 ft. long, and the top face is chequered to give a good foothold. Iron moulds are used for forming the kerbing.

The channel-blocks are 9 in. by 4 in. by 15 in. long (*Fig.* 17), and the upper face is slightly dished. They are cast in wood moulds face downwards.

The mixture used for making both the kerb and channel-blocks is 1 of Portland cement to 3 of Clee Hill granite chippings (¼ in. to dust). In mixing the materials great care is taken, as it has been found from experience that this is most essential or the results are not so good.

The aggregate is measured and well mixed with the cement, both before and after the water is added. As the moulds are being filled the material is rammed gently by means of a small wood rammer to obtain a good surface.

In 1878 the Brighton Corporation commenced making concrete kerbs and "pitchers," and they were laid in public highways for the first time in that year. Since then they have been extensively adopted.

The kerbs and pitchers at Brighton (see *Fig.* 18) have been made in the Corporation's own stores in iron moulds by hand and without pressure, the kerbs 30 in. by 11 in. by 5 in., and pitchers 18 in. by 6 in. by 4 in. They have been found to be a very useful and cheap substitute in the case of roads having ordinary traffic. They are made of 3 parts granite chippings, 1 part sand, and 2 parts cement, at a cost of 8*d.* per ft., against Purbeck stone at 1*s.* 3*d.*, and granite at 1*s.* 6*d.*

Concrete slabs were also made by hand, and the first were laid in 1881 in one of the busiest streets of the town and are still in existence; York stone laid adjoining has been replaced on two occasions.

Concrete kerb is being laid in the North Arterial Road, Middlesex, the length so far laid in the Edmonton District alone being 8,250 yards.

The proportions used on this work are 1 : 2 : 4.

The moulds consist of: (1) Face moulds of 4 in. by 3 in. timber in

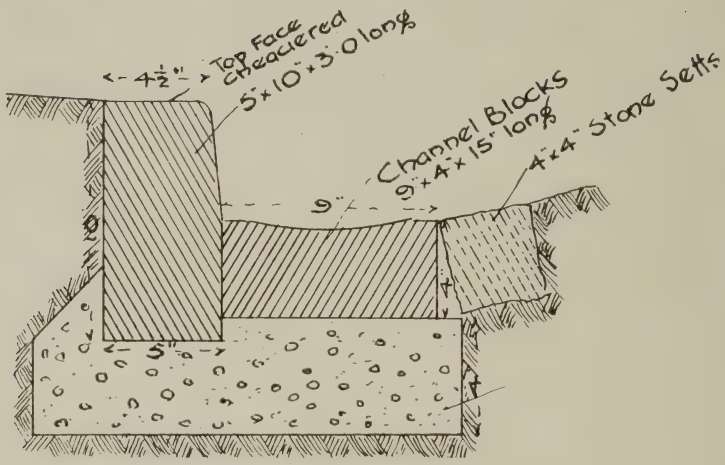


FIG. 17.—CONCRETE KERB AND SECTION CHANNEL IN AYLESBURY.

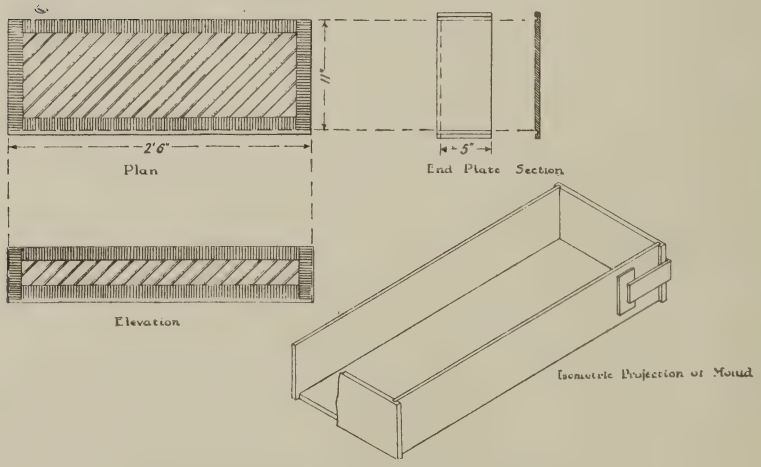


FIG. 18.—MOULDS FOR KERBS AT BRIGHTON.

6 ft. lengths ; (2) back shuttering of 12 in. by 1½ in. timber in 6 ft. lengths ; (3) steel bulkhead plates with lifting handles. Pegs were used for holding up the back shuttering and stretchers for keeping the back shuttering and front moulds an equal distance apart. *Fig.* 19 illustrates the various parts of the mould.

Before commencing concreting all moulds required for the day's work were fixed temporarily in position, and a good line obtained by packing or by means of small timber slips in between the back face of the front mould and the angle iron of the bulkhead plates. For keeping the top edge of the moulds level, the longest possible lengths of moulds were " boned " in and, where required, were packed up by small timber wedges or slips placed between the underside of the 4 in. by 3 in. face moulds and the top of the finished surface of the concrete road.

It was found advisable to half-draw the bulkhead plates by means of handles attached to them as soon as the concrete was sufficiently set. The whole plate was withdrawn approximately 14 hours after the placing of the concrete, leaving a small joint. It was found better not to grout or fill in this joint in any way.

The total cost for labour and materials was 2*s.* per ft. run nearly two years ago, when prices were higher than they are to-day. This work was carried out under the direction of Mr. A. Dryland, the County Engineer, and supervised by Mr. J. H. Jameson, the Resident Engineer. The labour was of the " unemployed " type.

The first concrete kerb put down in Surrey was a reinforced concrete submerged retaining wall or abutment to the carriage-way, and was evolved from considerations of, and investigations into, the apparent weakening of the road crust at the sides by movement or " creep " in the cross-fall direction where the roadside wastes were soft or the ditches unpiped, and was primarily intended to remedy such defects as arose from this cause. The kerb, 9 in. deep by 4 in. wide and reinforced with two steel rods ¼ in. diameter in the positions shown in *Fig.* 20, was laid *in situ*.

The kerb was put down to levels to coincide with the finished top or carpet coat of the carriage-way when laid. A trench 8 in. wide was excavated to required depths and 9 in. by 2 in. deal shuttering held in place with iron road-pins 4 in. apart. Concrete composed of 4 parts clean crushed ballast to pass a ½-in. mesh sieve, 2 parts clean sharp sand, and 1 part British Standard Specification Portland cement (all measures by bulk) was deposited between the shutters and tamped and trowelled off on top, and the reinforcing rods inserted as the work proceeded. The shutters were painted with soft soap and allowed

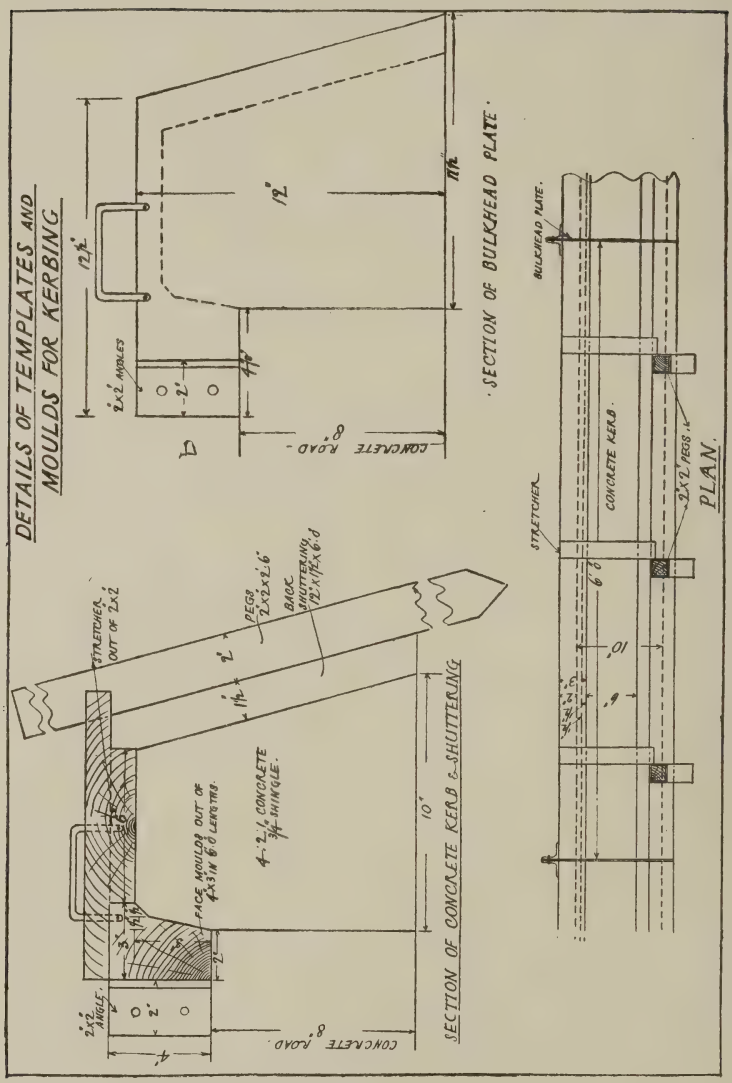


FIG. 19.—MOULDS FOR CONCRETE KERBING USED ON THE NORTH ARTERIAL ROAD, MIDDLESEX.

to remain for three days, when they were removed without difficulty and without detriment to the concrete kerb, which was immediately covered over with a small mound of earth and left to set for at least 28 days. Where the ground was sufficiently deep and compact and could be cut in a straight regular face, no shuttering was used on the

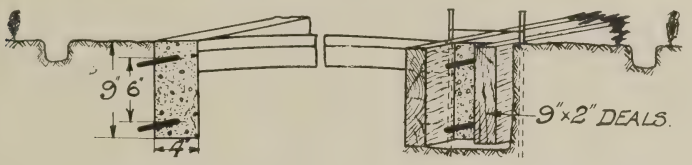


FIG. 20.—METHOD OF CONSTRUCTING SUBMERGED CONCRETE KERB.

back face. At bends or curves in the road 9 in. by 1 in. shutters were used to obtain an easy sweep. The kerb was continuous, and being practically submerged, and therefore not liable to great changes in temperature, no expansion joints were considered necessary, this conclusion being substantiated by the total absence of cracks, damage, or movement so far as observations can detect. This retaining kerb performs its functions successfully and is recommended by Mr. Alfred Dryland, County Surveyor of Surrey when the kerbing was laid, for use in rural areas where building developments are slow.

For use upon main roads and others in districts where footpaths are essential, an elaboration of this kerb was adopted, and is designed not only to retain the road crust but also to keep traffic within the boundaries of the carriage-way and form an edge to the footpath. It is shown in *Fig.* 21.

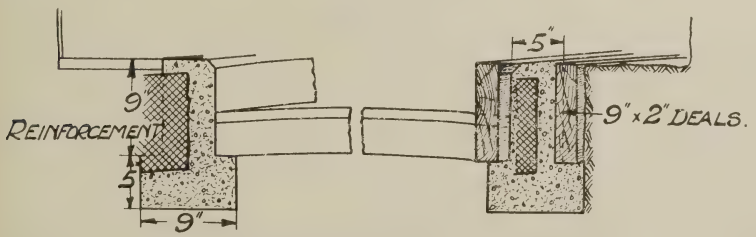


FIG. 21.—CONCRETE KERB FOR ROAD WITH FOOTPATH.

The trench in this case is dug 9 in. wide and generally to a depth of 14 in. below the intended path level, and a layer of concrete 9 in. wide and 5 in. thick composed of 5 parts ballast to pass a 1-in. mesh

sieve, 2 parts broken clinker and ashes, 1 part clean sharp sand, and 1 part Portland cement, is laid in the trench. The shutters, which are 9 in. by 2 in., planed on one face, and coated with oil or soft soap, are secured in position on this bed of concrete to show 5 in. between faces. The reinforcement is fixed in the line of neutral axis on a vertical plane in order to resist as far as possible reversals of normal stress, and it was contemplated that in this position it would oppose the necessary tensile resistance to any bending and unbalanced stresses brought to bear upon it in any direction and avoid the cost of two lines of reinforcement. It consists of a strip of expanded metal $\frac{3}{4}$-in. diamond mesh 9 in. wide, cut in lengths of about 16 ft. for convenient handling. To ensure continuity of the reinforcement an overlap of about 2 in. is arranged at each join, but to provide for expansion of the concrete joints are made at every 15 to 18 ft. by introducing a layer of tarred felt into the cross-section of the kerb. This is slit and passed over the reinforcement. Five-to-one concrete is then poured in to such a height as will bring the kerb to road level, and above the road level a three-to-

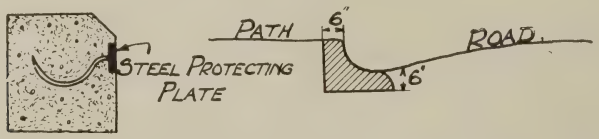


FIG. 22.—METHOD OF PROTECTING KERB BY STEEL PLATES.

one concrete, consisting of 1 part $\frac{1}{2}$-in. crushed ballast, 1 part $\frac{1}{8}$-in. to dust granite chippings (to give case hardening), 1 sand, and 1 Portland cement, is added and tamped against the shutters and smoothed off on top. To eliminate the sharp angular edge a chamfer is trowelled on the kerb about 1 in. wide, or to effect the same purpose a hard wood fillet can be nailed to the front shutter. On gradients, where traffic in many instances uses the kerb to form a "drag" upon the vehicle, a protecting steel strip is embodied in the kerb immediately below the chamfer. It is $1\frac{1}{4}$ in. by $\frac{3}{16}$ in., and is secured every 2 ft. by bent wire nails as shown in *Fig.* 22. The nails are countersunk into the steel and finished flush.

It is essential when removing the shutters to cover over the kerb for at least a month to ensure thorough setting, as it is subjected to a considerable amount of grinding and buffeting from the wheels of vehicles. Many miles of this kerb have been laid, the cost being little more than one-third the cost of granite. For this class of work a gang of eight men is required, and, when experienced, 50 to 60 yards per day

can be averaged. The shutters can be used many times over, and by hooping the ends before use the life of the boards is greatly increased.

In connection with the East to West Road now under construction in the county of Surrey, a very extensive use is being made of concrete kerbing.

INTEGRAL KERB.

Where concrete footpaths are laid, a method more recently adopted is that of forming the kerb *in situ* as part of the footpath itself. This is done by erecting a planed 3-in. plank along the kerb line in a trench, the kerb and paving being laid together with a joint every 6 ft. In this method the greatest care is required in the alignment of the planks ; they must be very rigidly supported with stakes, or bulging will occur. The cost is rather less than when the kerbing is moulded separately.

PAVEMENT GUTTERS.

During the war experiments were made with concrete gutters. They are cast in a wood mould with a 3-in. iron pipe running through the mould. If care is taken in the casting and when being fixed, they are found equal to iron gutters. *Fig.* 23 shows a gutter of this type as used at Aylesbury.

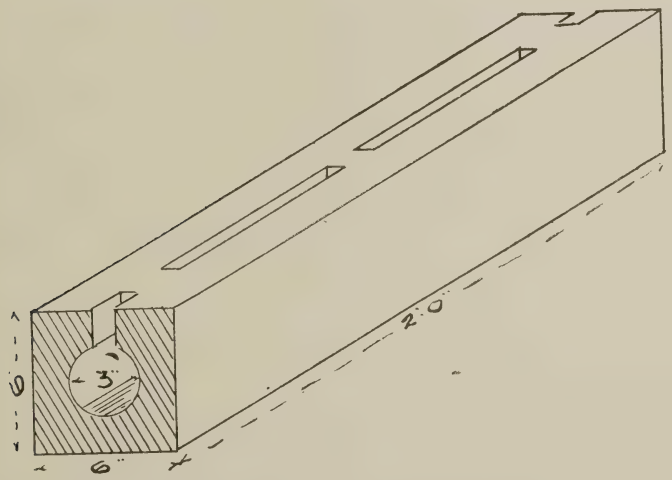


Fig. 23.—Concrete Pavement Gutter at Aylesbury.

CHAPTER 10.

TABLES FOR REINFORCED CONCRETE DESIGN.

We give in the following pages eight tables of the strength of reinforced concrete slabs, which have been prepared by Dr. Oscar Faber, O.B.E., D.Sc., A.M.Inst.C.E.

These Tables are based on the use of concrete having a strength of about 1,800 lb. per sq. in. at the end of one month, and about 2,400 lb. per sq. in. at the end of three months.

The highest stress used in the Tables is 600 lb. per sq. in. in the concrete, so that the Tables would give a factor of safety of 3 at the end of one month and a factor of safety of 4 at the end of three months.

The safe stress in the steel is taken as 16,000 lb. per sq. in.

Any reinforcement having a break in strength of 30 tons per sq. in. and an elastic limit of 15 tons per sq. in. is suitable, but plain mild steel rods to British Standard Specification are recommended.

The rods should be hooked at the ends of all slabs, and in the case of continuous slabs (Tables 4 and 5, also 7 and 8) half the rods should be bent up and kept at the top of the slab over the continuous support and for a distance of one-fifth of the span into the next span.

It will be noticed that the Tables give, by inspection, the safe load for any size of slab on any span, and altogether reduce the design to a question of simple inspection from the Tables.

All these assumptions are in accordance with the recommendations of the London County Council, and the cover of concrete round the reinforcement has been taken as $\frac{1}{2}$ in. or the diameter of the rod, whichever is the greater.

It will be noticed that various size rods may be used for any particular slab thickness, and that the necessary spacing for any such size is given; but on the right-hand side of Table 1 is given the size and spacing which are specially recommended for a given size slab where it is readily procurable, and it is this first rod from which the cover of concrete has been calculated.

TABLES FOR REINFORCED CONCRETE DESIGN.—I.

REINFORCEMENTS FOR SOLID SLABS.

Thickness of Slab, h. In.	Cross-sectional Area per ft. width of Slab, A_S. Sq. in.*	Centres apart in Inches of various Rods.								Practical Arrangement recommended.		Area Steel per ft. width supplied. A_S. In.
		$\frac{5}{16}$ diam.	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	Diameter of Rods. In.	Spacing. In.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
3	·187	4·93	7·06	9·74						$\frac{5}{16}$	5	·184
$3\frac{1}{2}$	·228		5·80	7·90	10·3					$\frac{3}{8}$	6	·220
4	·263		5·02	6·84	8·93	13·9				$\frac{3}{8}$	5	·264
$4\frac{1}{2}$	·304		4·34	5·92	7·74	12·1				$\frac{7}{16}$	6	·300
5	·344			5·24	6·83	10·7				$\frac{1}{2}$	7	·336
6	·410				5·75	9·0	12·9			$\frac{5}{8}$	9	·408
7	·491				4·78	7·49	10·7			$\frac{5}{8}$	$7\frac{1}{2}$	·490
8	·556					6·61	9·5	13·0		$\frac{3}{4}$	$9\frac{1}{2}$	·556
9	·637					5·79	8·3	11·3		$\frac{3}{4}$	$8\frac{1}{2}$	·624
10	·704						7·5	10·2	13·4	$\frac{7}{8}$	10	·721
11	·785						6·74	9·1	12·0	1	12	·785
12	·850							8·48	11·1	1	11	·857

* Based on 0·675 per cent.

TABLES FOR REINFORCED CONCRETE DESIGN.—II.

PROPERTIES OF SOLID SLABS.

h Thickness.	Area of Steel, As.	Cover of Concrete.	h-d Centre of Rod to Bottom of Slab.	Effective Depth, d.	Radius Arm, a.	Depth to Neutral Axis, n.	Section Modulus Steel Units.	Moment of Resistance 1,000 lb.-ins. Units.*	Total Moment of Inertia.	
									Steel Units.	Concrete Units.†
In.	Sq. in.‡	In.	In.	In.	In.	In.	In.^{3}		In.^{4}	In.^{4}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
3	·187	·50	·69	2·31	2·03	·831	·38	6·08	·56	8·4
3½	·228	·50	·69	2·81	2·47	1·01	·59	9·00	1·07	16·1
4	·263	·50	·75	3·25	2·86	1·17	·76	12·07	1·57	23·5
4½	·304	·50	·75	3·75	3·30	1·35	1·00	16·02	2·40	36·0
5	·344	·50	·75	4·25	3·74	1·53	1·29	20·60	3·50	52·6
6	·410	·63	·94	5·06	4·45	1·82	1·83	29·2	5·92	88·8
7	·491	·63	·94	6·06	5·33	2·18	2·61	41·9	10·2	152·6
8	·556	·75	1·13	6·87	6·05	2·47	3·37	53·7	14·8	222·1
9	·637	·75	1·13	7·87	6·92	2·83	4·42	70·5	22·2	333·0
10	·704	·87	1·31	8·69	7·65	3·13	5·38	86·1	29·9	449·8
11	·785	·87	1·31	9·69	8·52	3·49	6·70	107·0	41·5	622·8
12	·850	1·00	1·50	10·50	9·24	3·78	7·86	125·7	52·8	792

* Working to stresses of 16,000 lb./in.^{2} and 600 lb./in.^{2} in the steel and concrete respectively.

† Modular ratio 15.

‡ 0·675 per cent.—Col. 2, Table I.

TABLES FOR REINFORCED CONCRETE DESIGN.—III.

SOLID SLABS.

Safe distributed total loads in lb. per sq. ft., including the dead weight of slab.

Slabs free-ended. Bending moment $B = \frac{Wl}{8}$.

h Thickness. In.	Spans in Feet.											
	4	5	6	7	8	9	10	12	14	16	18	20
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
3	253	162	112	83	63							
$3\frac{1}{2}$	374	239	166	123	94	74						
4	501	321	223	165	126	99	80					
$4\frac{1}{2}$		428	298	220	168	132	107	75				
5			382	282	215	170	137	96	70			
6			540	399	321	240	194	135	99			
7				570	436	344	279	194	142	109		
8					562	443	368	249	183	140	111	
9						581	460	327	240	184	145	
10							574	399	293	224	177	143
11								496	364	279	220	178
12								581	427	326	258	209

Based on stresses of 600 lb./in.^{2} in the concrete and 16,000 lb./in.^{2} in the steel.
Reinforcement as Table I.
Properties of slabs as Table II.

TABLES FOR REINFORCED CONCRETE DESIGN.—IV.

SOLID SLABS.

Safe distributed total loads in lb. per sq. ft., including the dead weight of slab.
Slabs continuous one end.

Bending moment $B = \frac{Wl}{10}$.

h Thickness. In.	Spans in Feet.											
	4	5	6	7	8	9	10	12	14	16	18	20
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
3	316	202	140	103	79							
$3\frac{1}{2}$	468	300	208	153	107	92	75					
4	626	401	278	205	156	124	100	70				
$4\frac{1}{2}$		535	372	273	209	167	134	93	68			
5			478	351	268	212	172	9	88			
6				496	379	300	243	169	124	95		
7					543	430	348	242	178	136	117	
8						554	448	312	239	175	138	112
9							588	408	300	230	181	147
10								498	366	280	221	180
11								620	455	348	275	223
12								725	534	408	322	262

Based on stresses of 600 lb./in.^{2} in the concrete and 16,000 lb./in.^{2} in the steel.
Reinforcement as Table I.
Properties of slabs as Table II.

TABLES FOR REINFORCED CONCRETE DESIGN.—V.

SOLID SLABS.

Safe distributed total loads in lb. per sq. ft., including the dead weight of slab.
Slabs continuous both ends.

Bending moment $B = \frac{Wl}{12}$.

h Thickness. In.	Spans in Feet.											
	4	5	6	7	8	9	10	12	14	16	18	20
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
3	379	243	169	124	95	75						
$3\frac{1}{2}$	562	360	250	184	140	111	90					
4		481	334	246	188	149	120	75				
$4\frac{1}{2}$			446	328	251	199	161	112	82			
5			524	422	323	256	206	144	105	81		
6					456	361	292	203	149	114	90	
7						518	418	291	212	163	129	105
8							539	374	275	210	166	135
9							706	490	360	275	218	176
10								598	440	336	266	215
11									546	418	330	268
12									641	490	387	314

Based on stresses of 600 lb./in.^{2} in the concrete and 16,000 lb./in.^{2} in the steel.
Reinforcement as Table I.
Properties of slabs as Table II.

TABLES FOR REINFORCED CONCRETE DESIGN.—VI.

SOLID SLABS.

Safe distributed live loads in lb. per sq. ft., excluding the dead weight of slab.
Slabs free-ended.

Bending moment $B = \frac{Wl}{8}$.

h Thickness. In.	Spans in Feet.											
	4	5	6	7	8	9	10	12	14	16	18	20
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
3	215	124	74	45	25							
$3\frac{1}{2}$	330	195	122	79	50	30						
4	451	271	173	115	76	49	30					
$4\frac{1}{2}$		372	242	164	112	76	51	19				
5			319	219	152	107	74	33	7			
6			465	324	246	165	119	60	24			
7				482	348	256	191	106	54	21		
8					462	343	268	149	83	40	11	
9						469	348	215	128	72	33	
10							449	274	168	99	152	18
11								358	226	141	82	40
12								431	277	176	108	59

Based on stresses of 600 lb./in.^{2} in the concrete and 16,000 lb./in.^{2} in the steel.
Reinforcement as Table I.
Properties as Table II.

TABLES FOR REINFORCED CONCRETE DESIGN.—VII.

SOLID SLABS.

Safe distributed live loads in lb. per sq. ft., excluding the dead weight of slab.
Slabs continuous one end.

Bending moment $B = \frac{Wl}{10}$.

h Thickness. In.	Spans in Feet.											
	4	5	6	7	8	9	10	12	14	16	18	20
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
3	278	164	102	65	41							
$3\frac{1}{2}$	424	256	164	109	63	48	31					
4	576	351	228	155	106	74	50	20				
$4\frac{1}{2}$		479	316	217	153	151	78	37	12			
5			415	288	205	149	109	56	25			
6				421	304	225	168	94	49	20		
7					455	342	260	154	90	48	29	
8						454	348	212	139	75	38	12
9							476	296	188	118	69	35
10								373	241	155	196	55
11								482	317	210	137	85
12								575	384	258	172	112

Based on stresses of 600 lb./in.^{2} in the concrete and 16,000 lb./in.^{2} in the steel.
Reinforcement as Table I.
Properties as Table II.

TABLES FOR REINFORCED CONCRETE DESIGN.—VIII.

SOLID SLABS.

Safe distributed live loads in lb. per sq. ft., excluding the dead weight of slab.
Slabs continuous both ends.

Bending moment $B = \frac{Wl}{12}$.

h Thickness.	Spans in Feet.											
In.	4	5	6	7	8	9	10	12	14	16	18	20
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
3	341	205	131	86	57	37						
$3\frac{1}{2}$	518	316	206	140	96	67	46					
4		431	284	196	138	99	70	25				
$4\frac{1}{2}$			390	272	195	143	105	56	26			
5			461	359	260	193	143	81	42	18		
6					381	286	217	128	74	39	15	
7						430	330	203	124	75	41	17
8							439	274	175	110	66	35
9							594	378	248	163	106	64
10								473	315	211	141	90
11									408	280	192	130
12									491	340	237	164

Based on stresses of 600 lb./in.^{2} in the concrete and 16,000 lb./in.^{2} in the steel.
Reinforcement as Table I.
Properties as Table II.

CHAPTER 11.

MEMORANDA FOR CONCRETE USERS.

WEIGHTS AND DIMENSIONS OF CONCRETE AND ITS CONSTITUENT PARTS.

Cement.—1 ton of Portland cement = 10 sacks of 2 cwts. (224 lb. net) each ; or 11 sacks of 204 lb. net each ; or 12 sacks of 187 lb. net each.

1 cu. ft. of Portland cement weighs from 75 to 90 lb. when loosely filled in without any shaking, and about 110 lb. when tightly packed.

The Royal Institute of British Architects advises the adoption of 90 lb. as the basis of comparison in converting cement from cu. ft. to lb. for proportioning concrete. This has also been adopted as the standard by the London County Council in their Regulations for Reinforced Concrete Construction in London.

1 cu. ft. = ·037 cu. yd. = 1,728 cu. in.

1 cu. yd. = 27 cu. ft. = 46,656 cu. in. = 1 load.

1 ton = 20 cwts. = 2,240 lb. = 35,840 ozs.

Water.—1 cu. ft. of fresh water weighs 62·4 lb. = 6·23 gallons = ·037 cu. yd.

1 gallon of water = 10 lb. = ·16 cu. ft. = 277·46 cu. in.

1 cu. ft. of salt water weighs 64 lb. = 6·23 gallons.

Concrete.—Average weight of 1 : 2 : 4 concrete : Coke-breeze as coarse material, 100 lb. per cu. ft. ; clinker, 110 lb. per cu. ft. ; brick, 125 lb. per cu. ft. ; limestone, 135 lb. per cu. ft. ; shingle as coarse material, 145 lb. per cu. ft.

Average weight of 1 : 2 : 4 reinforced concrete : 150 lb. per cu. ft.

Sand and Aggregate.—1 ton = 21 cu. ft. river sand = 22 cu. ft. pit sand = 22 cu. ft. ballast = 23 cu. ft. coarse gravel = 24 cu. ft. clean shingle.

Wheel-barrow.—An average wood wheel-barrow is made to contain $\frac{1}{10}$ cu. yd. of heaped wetted material.

Average load of broken stone or ballast for wood wheel-barrow = 2·4 cu. ft.

Average load of sand for wood wheel-barrow = 2·5 cu. ft.

Large load of broken stone or ballast for average iron wheel-barrow = 3·0 cu. ft.

Large load of sand for iron wheel-barrow = 3·5 cu. ft.

Average load of ordinary concrete (rammed) for iron wheel-barrow = 1·9 cu. ft.

Large load of concrete for iron wheel-barrow = 2·2 cu. ft.

Strength of Concrete at Various Ages.—Approximate percentage of strength of concrete at different ages in comparison with the strength at 1 year :—

28 days old	60 per cent.
2 months ,,	75 ,,
3 ,, ,,	85 ,,
4 ,, ,,	90 ,,
6 ,, ,,	95 ,,
1 year ,,	100 ,,

Safe compressive strength of 1 : 2 : 4 concrete = 600 lb. per sq. in. With modern cements this allows of the factor of safety reaching 6 to 1 or even more.

The crushing strain of 1 : 2 : 4 concrete, with modern cements, at 28 days = about 4,000 lb. per sq. in.

Reinforcement.—Safe adhesion strength of concrete to steel = 100 lb. per sq. in. of area of metal.

Ultimate strength of mild steel in tension = 60,000 lb. per sq. in.

Safe strength of mild steel in tension = 16,000 lb. per sq. in.

Proportions of Cement for Concrete.—0·87 cu. ft. of neat cement mortar will result from mixing 0·36 cu. ft. of water with 1 cu. ft. of loose cement.

1 cu. ft. of loose Portland cement will make about :

4·1 cu. ft. of concrete mixed	1 : 2 : 4
5 ,, ,, ,,	1 : 2½ : 5
5·8 ,, ,, ,,	1 : 3 : 6
7·5 ,, ,, ,,	1 : 4 : 8

Areas covered by 1 cu. ft. of Cement and Concrete.—1 cu. ft. of loose Portland cement neat as cement mortar will cover about 10·4 sq. ft. 1 in. thick.

1 cu. ft. of loose Portland cement to 1 sand will cover about 17 sq. ft. 1 in. thick.

1 cu. ft. of loose Portland cement to 2 sand will cover about 25 sq. ft. 1 in. thick.

1 cu. ft. of loose Portland cement to 3 sand will cover about 34 sq. ft. 1 in. thick.

1 cu. ft. of loose Portland cement to 2 sand will lay about 146 bricks with $\frac{3}{8}$ in. joint or 247 bricks with $\frac{1}{4}$ in. joint.

1 cu. ft. of loose Portland cement to 3 sand will lay about 212 bricks with $\frac{3}{8}$ in. joint or 317 bricks with $\frac{1}{4}$ in. joint.

1 yd. super of pointing brick work in neat cement requires about 8 lb. of cement.

100 lb. of Portland cement and 1 cu. ft. of sand will plaster :

$2\frac{1}{4}$ sq. yds.	1 in. thick.
3 ,,	$\frac{3}{4}$,,
$4\frac{1}{4}$,,	$\frac{1}{2}$,,

100 lb. of Portland cement and 2 cu. ft. of sand will plaster :

3 sq. yds.	1 in. thick.
$4\frac{1}{4}$,,	$\frac{3}{4}$,,
$6\frac{1}{2}$,,	$\frac{1}{2}$,,

PROPORTION OF SOLIDS AND VOIDS IN VARIOUS COARSE MATERIALS.

Aggregates.	Solids.	Voids.
Sand, moist, fine, passing 18-mesh sieve (*i.e.*, 324 meshes to the sq. in.)	·57	·43
Sand, moist, coarse, not passing 18-mesh sieve	·65	·35
Sand, moist, coarse and fine mixed, ordinary	·62	·38
Sand, dry, coarse and fine mixed	·70	·30
Stone screenings and stone dust	·58	·42
Ballast, $\frac{3}{4}$ in. and under, 6 per cent. coarse sand	·67	·33
Broken stone, 1 in. and under	·54	·46
Broken stone, $2\frac{1}{2}$ in. and under, dust only screened out	·59	·41
Broken stone, 2 in. and under, most small stones screened out	·55	·45

MATERIALS REQUIRED FOR FLOORS, PER SQUARE YARD.

Proportions.	Materials.	4 in thick.	4½ in. thick.	5 in. thick.	5½ in. thick.	6 in. thick.	6½ in. thick.	7 in. thick.	7½ in. thick.	8 in. thick.	8½ in. thick.	9 in. thick.	9½ in. thick.	10 in. thick.	11 in. thick.	12 in. thick.
1 : 2 : 4	*Cement . lb.	59·3	66·75	74·16	81·58	89	96·42	103·83	111·25	118·66	126·08	133·5	140·92	148·33	163·16	178
	Sand . . cu. ft.	1·32	1·485	1·65	1·82	1·98	2·15	2·31	2·48	2·64	2·81	2·97	3·14	3·3	3·63	3·96
	Coarse matl. cu. ft.	2·64	2·97	3·3	3·63	3·96	4·29	4·62	4·95	5·28	5·61	5·94	6·27	6·6	7·26	7·92
1 : 2½ : 5	*Cement . lb.	48·9	55	61·1	67·2	73·3	79·4	85·5	91·6	97·7	103·8	110	116·1	122·2	134·4	146·6
	Sand . . cu. ft.	1·35	1·52	1·69	1·86	2·03	2·19	2·36	2·53	2·7	2·87	3·04	3·21	3·38	3·71	4·05
	Coarse matl. cu. ft.	2·7	3·04	3·38	3·72	4·05	4·39	4·73	5·06	5·4	5·74	6·08	6·41	6·75	7·43	8·1
1 : 3 : 6	*Cement . lb.	41·5	46·69	51·88	57·07	62·25	67·44	72·63	77·82	83	88·19	93·38	98·57	103·76	144·14	124·5
	Sand . . cu. ft.	1·43	1·62	1·79	1·97	2·15	2·33	2·51	2·69	2·87	3·05	3·23	3·41	3·58	3·95	4·3
	Coarse matl. cu. ft.	2·86	3·23	3·58	3·94	4·3	4·66	5·02	5·38	5·74	6·1	6·46	6·82	7·16	7·9	8·6

* Based on loose cement weighing 90 lb. per cu. ft.

MORTARS PRODUCED WITH ORDINARY (FINE AND COARSE MIXED) SAND.

Parts of sand mixed with 1 part of cement	1·0	1·5	2·0	2·5	3·0	3·5	4·0	5·0
Volume of slush mortar	1·4	1·78	2·17	2·55	2·98	3·39	3·82	4·65
Volume of dry facing mortar (rammed)	1·22	1·57	1·93	2·28	2·64	2·99	3·35	4·08

WEIGHTS OF VARIOUS SUBSTANCES IN LB. PER CUBIC FOOT.

	Lb. per cu. ft.
Aluminium	162
Asphalt rock	100
American ash	38
Ballast and sand, dry, loose	90 to 106
Ballast and sand, well shaken	99 to 117
Ballast and sand, thoroughly wet	120 to 140
Bell metal	502
Bitumen	87
Brass, cast	504
Brick, best pressed	*150
Brick, fire	*137
Brick, common hard	*125
Brick, soft, inferior	*100
Brickwork, pressed brick, in cement	140
Brickwork, ordinary	120
Cement, loose from sacks	75 to 90
Chalk	112
Clay, in lump, loose	63
Clay, solid	120
Coal, solid	82
Coal, broken, loose	49
Coke, loose	62·5
Concrete, mean	140
Copper, cast	537
Copper, sheet	550

* *See Note on p.* 114.

	Lb. per cu. ft.
Earth, common loam, dry, loose	76
Earth, common loam, dry, moderately rammed	95
Earth, compacted	136
Earth, as a soft, flowing mud	108
Elm, dry	35
Flint	*162
Glass, common window	157
Grain, at 60 lb. per bushel	48
Granite, Scotch	*164
Gravel, common, loose	109
Gun-metal	528
Hay	5
Hay, pressed	8
Hemlock, dry	25
Ice	57·4
India-rubber	60
Iron, cast	450
Iron, wrought	480
Lead	710
Lime, slaked	25 to 37
Limestone	*168
Limestone, loose broken	96
Marble	175
Masonry, dressed granite or limestone	*165
Masonry, dressed rubble set in mortar	154
Masonry, dressed rubble, dry	*138
Masonry, dressed sandstone	*144
Mortar, hardened	103
Mud, dry, close	80 to 110
Mud, wet, fluid, maximum	120
Oak, dry	59

*See Note on p. 114.

	Lb. per cu. ft.
Petroleum	55
Pumice stone	57
Pine, white, dry	25
Pine, yellow	34 to 45
Pine, pitch	65
Plaster of Paris, cast	80
Quartz	*165
Quicklime, ground, loose, or in small lumps	53
Quicklime, ground, loose, thoroughly shaken	75
Red lead	557
Salt, loose	50 to 70
Salt, solid	133
Sand, pure quartz, perfectly dry, loose	89 to 106
Sand, pure quartz, perfectly dry, slightly shaken	92 to 110
Sand, natural, dry, maximum	117
Sand, thoroughly wet, voids full of water	118 to 120
Shale	162
Slate	175
Snow, freshly fallen	5 to 12
Snow, moistened and compacted by rain	15 to 50
Spar, calcareous	171
Spelter or zinc	438
Spruce, dry	25
Steel	490
Stone, Bath	*122
Stone, Basalt	*164
Stone, Kentish rag	*165
Stone, Portland	*148
Stone, Sandstone	*137
Stone, Traprock	*169
Tallow	58·6
Tar	62
Tile	113
Tin	406

* *See Note on p.* 114.

	Lb. per cu. ft.
Water, pure, at 39·2° F., or 4° C. (for basis of determining specific gravity)	62·425
Water, rain, at 60° F.	62·3
Water, sea (salt)	64
Zinc	438

Green timbers weigh $\frac{1}{5}$ to $\frac{1}{2}$ more than dry.

* These weights are for solid materials, not crushed or broken; allowances must be made for the weights of broken materials varying with the percentage of voids.

WEIGHT OF SQUARE AND ROUND STEEL.

WEIGHT OF STEEL TAKEN AS 41 LB. PER SQUARE FOOT, 1 IN. THICK.

Side of Square or Diam. in ins.	SQUARE.		ROUND.	
	Lb. per ft.	Lineal feet in 1 cwt.	Lb. per ft.	Lineal feet in 1 cwt.
$\frac{1}{4}$	·22	524	·17	667
$\frac{5}{16}$	·34	336	·26	428
$\frac{3}{8}$	·48	233	·38	297
$\frac{7}{16}$	·66	171	·52	218
$\frac{1}{2}$	·86	131	·67	167
$\frac{9}{16}$	1·08	104	·85	132
$\frac{5}{8}$	1·33	84	1·05	107
$\frac{11}{16}$	1·61	69	1·27	88
$\frac{3}{4}$	1·92	58	1·51	74
$1\frac{3}{16}$	2·26	49	1·77	63
$\frac{7}{8}$	2·62	43	2·05	54
$\frac{15}{16}$	3·00	$37\frac{1}{2}$	2·46	45
1	3·42	33	2·68	42
$1\frac{1}{8}$	4·33	26	3·39	33
$1\frac{1}{4}$	5·34	21	4·19	27
$1\frac{3}{8}$	6·46	$17\frac{1}{2}$	5·07	22
$1\frac{1}{2}$	7·69	$14\frac{1}{2}$	6·04	$18\frac{1}{2}$

MATERIALS FOR 1 CU. YD. OF CONCRETE.

Based on loose cement weighing 90 lb. per cu. ft. and a cu. ft. of loose, moist, coarse sand weighing 89 lb. when dry.

Proportions.	Coarse Material.	Lb. Portland Cement in 1 cu. yd.	Sand cu. yds. in 1 cu. yd.	Coarse Material cu. yds. in 1 cu. yd.
1 : 1 : 2	Shingle (40 per cent. voids)	869	·36	·71
Do.	Broken stone (45 per cent. voids) . .	902	·37	·74
1 : 1½ : 3	Shingle	666	·41	·82
Do.	Broken stone (45 per cent. voids) . .	697	·43	·86
1 : 1⅔ : 3⅓	Shingle	610	·42	·84
Do.	Broken stone . .	640	·44	·88
1 : 2 : 4	Shingle	520	·43	·86
Do.	Broken stone . .	548	·45	·90
1 : 2½ : 5	Shingle	430	·44	·88
Do.	Broken stone . . .	450	·46	·92
1 : 3 : 6	Shingle	364	·45	·90
Do.	Broken stone . .	383	·47	·94
1 : 4 : 8	Shingle	280	·46	·92
Do.	Broken stone . .	294	·48	·97

CHAPTER 12.

BIBLIOGRAPHY OF CONCRETE AND REINFORCED CONCRETE.

In the following list we have included, as far as possible, all the books printed in the English language dealing with concrete and reinforced concrete, cement, and one or two other subjects of interest to the industry. In nearly all cases further particulars, in the form of a prospectus, may be obtained from the publishers. The prices given are the net prices at which the books may be obtained through a bookseller; if they are ordered by post, the postage is extra.

The different sections are arranged alphabetically according to the names of the authors.

DESIGN AND CONSTRUCTION.

Reinforced Concrete Construction in Theory and Practice. By H. Adams and E. R. Matthews. (Longmans, Green.) 15*s.*

Detail Design—Reinforced Concrete. By Ewart S. Andrews. (Sir Isaac Pitman.) 6*s.*

Elastic Stresses in Structures. By Ewart S. Andrews. (Scott, Greenwood.) 25*s.*

Elementary Principles of Reinforced Concrete Construction. By Ewart S. Andrews. (Scott, Greenwood.) 5*s.*

Theory and Design of Structures. By Ewart S. Andrews. (Chapman & Hall.) 13*s.* 6*d.*

Further Problems in the Theory and Design of Structures. By Ewart S. Andrews. (Chapman & Hall.) 10*s.*

Reinforced Concrete and Steelwork Regulations of the London County Council. By Ewart S. Andrews. (Batsford.) 3*s.* 6*d.*

Masonry Construction. By I. O. Baker. (Chapman & Hall.) 25*s.*

Reinforced Concrete Railway Structures. By J. D. W. Ball. (Constable.) 9*s.*

Reinforced Concrete. By Brooks. (McGraw-Hill.) 10*s.*

Reinforced Concrete. By Buel and Hill. (McGraw-Hill.) 30*s.*

Reinforced Concrete Construction. By M. T. Cantell. (Spon.) Vol. I, 8*s*. 6*d*. ; Vol. II, 16*s*.

Reinforced Concrete. By A. Considère. (McGraw-Hill.) 10*s*.

Graphical Reinforced Concrete Design. By J. A. Davenport. (Spon.) 6*s*.

Diagrams for the Design of Reinforced Concrete Structures. By G. F. Dodge. (McGraw-Hill.) 20*s*.

Reinforced Concrete Simply Explained. By Oscar Faber. (Henry Frowde and Hodder & Stoughton.) 5*s*.

Reinforced Concrete Design. By Oscar Faber. (Edward Arnold.) Vol I : Theory, 14*s*. ; Vol II : Practice, 18*s*.

Simple Designs in Reinforced Concrete. By Oscar Faber. (Henry Frowde and Hodder & Stoughton.) 5*s*.

Reinforced Concrete Design Simplified. By J. C. Gammon. (Crosby Lockwood.) 10*s*. 6*d*.

Continuous Beams in Reinforced Concrete. By Burnard Geen. (Chapman & Hall.) 10*s*.

Concrete Construction. By H. P. Gillette and C. S. Hill. (McGraw-Hill.) 25*s*.

Concrete Work. By W. K. Hatt and W. C. Voss. (Chapman & Hall.) Vol. I, 23*s*. ; Vol. II, 10*s*.

Answers to Concrete Work. By W. K. Hatt and W. C. Voss. (Chapman & Hall.) 1*s*. 3*d*.

Reinforced Concrete Construction. By Hool. (McGraw-Hill.) Vol. I, 12*s*. 6*d*. ; Vol. II, 30*s*. ; Vol. III, 30*s*.

Elements of Structures. By G. A. Hool. (McGraw-Hill.) 8*s*. 9*d*.

Concrete Designers' Manual. By G. A. Hool and C. S. Whitney. (McGraw-Hill.) 20*s*.

Structural Members and Connections. By G. A. Hool and W. S. Kinne. (McGraw-Hill.) 30*s*.

Reinforced Concrete : A Practical Handbook for Use in Design and Construction. By R. J. Harrington Hudson. (Chapman & Hall.) 16*s*.

Elements of Graphic Statics. By Hudson and Squire. (McGraw-Hill.) 6*s*. 3*d*.

Reinforced Concrete. By McCullough. (McGraw-Hill.) 7*s*. 6*d*.

Reinforced Concrete Design. By G. P. Manning. (Longmans, Green.)

Reinforced Concrete—Compression Member Diagrams. By C. F. Marsh. (Constable.) 5*s*.

Concise Treatise on Reinforced Concrete. By C. F. Marsh. (Constable.) 12*s*. 6*d*.

Manual of Reinforced Concrete. By C. F. Marsh and W. Dunn. (Constable.) 21*s.*

Properties and Design of Reinforced Concrete. By N. Martin. (Constable.) 8*s.*

Tables for Reinforced Concrete Floors and Roofs. By R. Travers Morgan. (Chapman & Hall.)

Concrete-Steel Construction. By Morsch. (McGraw-Hill.) 25*s.*

Reinforced Concrete Calculations in a Nutshell. By J. T. Piggott. (Spon.) 3*s.* 6*d.*

Concrete: Its Uses in Building from Foundation to Finish. By T. Potter. (Batsford.) 8*s.* 6*d.*

Reinforced Concrete Buildings. By Ransome and Saurbrey. (McGraw-Hill.) 12*s.* 6*d.*

Concrete and Reinforced Concrete Construction. By Reid. (McGraw-Hill.) 25*s.*

Reinforced Concrete: Theory and Practice. By F. Rings. (Batsford.) 10*s.* 6*d.*

Second Report of the Committee of the Royal Institute of British Architects on Reinforced Concrete. (Batsford.) 1*s.*

Columns: A Treatise on the Strength and Design of Compression Members. By E. H. Salmon. (Henry Frowde and Hodder & Stoughton.) 31*s.* 6*d.*

Reinforced Concrete in Practice. By A. Alban H. Scott. (Scott, Greenwood.) 5*s.*

Treatise on Concrete: Plain and Reinforced. By F. W. Taylor and S. E. Thompson. (Chapman & Hall.) 30*s.*

Extracts on Reinforced Concrete Design. By F. W. Taylor and S. E. Thompson. (Chapman & Hall.) 9*s.* 6*d.*

Elements of Structural Design. By H. R. Thayer. (Constable.) Vol. I: Elements, 19*s.*; Vol. II: Design of Simple Structures, 16*s.*

Reinforced Concrete Design Tables. By Thomas and Nichols. (McGraw-Hill.) 15*s.*

Concrete: Plain and Reinforced. By J. C. Trautwine, junr., and J. C. Trautwine. (Chapman & Hall.) 5*s.*

Principles of Reinforced Concrete Construction. By F. E. Turneaure and E. R. Maurer. (Chapman & Hall.) 20*s.*

Reinforced Concrete. By W. Noble Twelvetrees. (Sir Isaac Pitman.) 21*s.*

Simplified Methods of Calculating Reinforced Concrete Members. By W. Noble Twelvetrees. (Sir Isaac Pitman.) 5*s.*

Practical Design of Reinforced Concrete Beams and Columns. By W. Noble Twelvetrees. (Sir Isaac Pitman.) 7*s*. 6*d*.

Concrete and Reinforced Concrete: Introductory. By W. Noble Twelvetrees. (Pitman.) 3*s*.

Engineering Construction. By W. H. Warren. (Longmans, Green.) Part I: In Steel and Timber, 30*s*.; Part II: In Masonry and Concrete, 36*s*.

Reinforced Concrete Diagrams. By J. Williamson. (Constable.) 12*s*.

Graphical Analysis. By W. S. Wolfe. (McGraw-Hill.) 20*s*.

BRIDGES AND ARCHES.

Loads on Highway Bridges (Report of the Joint Committee of the Concrete Institute, the Institution of Municipal and County Engineers, and the Institution of Municipal Engineers). (Spon.) 2*s*. 6*d*.

Moving Loads on Railway Underbridges. By H. Bamford. (Sir Isaac Pitman.) 5*s*. 6*d*.

Bridge Foundations. By W. Burnside. (Scott, Greenwood.) 5*s*.

Plain and Reinforced Concrete Arches. By J. Melan. (Chapman & Hall.) 12*s*. 6*d*.

Notes on Cylinder Bridge Piers and the Well System of Foundations. By J. Newman. (Spon.) 7*s*. 6*d*.

Theory and Design of Reinforced Concrete Arches. By Reuterdahl. (McGraw-Hill.) 10*s*.

Reinforced Concrete Bridges. By F. Rings. (Constable.) 21*s*.

Stability of Arches. By E. H. Sprague. (Scott, Greenwood.) 5*s*.

Bridge Engineering. 2 Vols. By J. A. L. Waddell. (Chapman & Hall.) 60*s*.

EARTH PRESSURES AND FOUNDATIONS.

Earth Dams. By B. Bassell. (McGraw-Hill.) 7*s*. 6*d*.

Earth Pressure, Retaining Walls, and Bins. By W. Cain. (Chapman & Hall.) 14*s*.

Retaining Walls—Theory and Practice. By T. E. Coleman. (Spon.) 6*s*.

Allowable Pressures on Deep Foundations. By E. L. Corthell. (Chapman & Hall.) 6*s*. 6*d*.

Railway and Other Earthwork Tables. By C. L. Crandall. (Chapman & Hall.) 7*s*. 6*d*.

Methods for Earthwork Computations. By C. W. Crockett. (Chapman & Hall.) 7*s*. 6*d*.

Earthwork Haul and Overhaul. By J. C. L. Fish. (Chapman & Hall.) 10*s.*

Engineering and Building Foundations. Vol. I: Ordinary Foundations. By C. E. Fowler. (Chapman & Hall.) 25*s.*

Earthwork and its Cost. By H. P. Gillette. (McGraw-Hill.) 30*s.*

Grace's Earthwork Tables. (Spon.) 12*s.* 6*d.*

Foundations, Abutments and Footings. By G. A. Hool and W. S. Kinne. (McGraw-Hill.) 20*s.*

Retaining Walls for Earth. By M. A. Howe. (Chapman & Hall.) 9*s.*

Foundations. By M. A. Howe. (Chapman & Hall.) 7*s.* 6*d.*

Foundations of Bridges and Buildings. By H. S. Jacoby and R. P. Davis. (McGraw-Hill.) 30*s.*

Tables for Computing the Contents of Earthwork. By W. Macgregor. (Spon.) 6*s.*

Earthwork Slips and Subsidences. By J. Newman. (Spon.) 7*s.* 6*d.*

Retaining Walls (Their Design and Construction). By G. Paaswell. (McGraw-Hill.) 20*s.*

Stability of Masonry and other Structures subject to the Pressure of Earth and Water. By E. H. Sprague. (Scott, Greenwood.) 5*s.*

Prismoidal Formulæ and Earthwork. By T. U. Taylor. (Chapman & Hall.) 7*s.* 6*d.*

Modern Underpinning. By L. White and E. A. Prentis. (Chapman & Hall.) 7*s.* 6*d.*

Design of Masonry Structures and Foundations. By C. C. Williams. (McGraw-Hill.) 25*s.*

CONCRETE HOUSES AND COTTAGES.

The Concrete House. By G. W. Hilton. (Spon.) 1*s.* 6*d.*

Concrete Cottages. By Albert Lakeman. (Concrete Publications, Ltd.)

[A second edition of this work, rewritten and brought thoroughly up to date, will be ready in the spring of 1924. The new edition is written on different lines from the first edition, and should be of very great value to all interested in the provision of small houses. The author has taken seven types of concrete buildings—(1) a two-bedroom house, (2) a three-bedroom house, (3) a block of four houses, including two of each of types (1) and (2), (4) a bungalow with two bedrooms, (5) a week-end bungalow, (6) a garage for two cars and (7) a garage for one car—and each of these buildings is so dealt with that they can be erected by any builder from the

drawings and information contained in the book. For each building elevations (both with a flat roof and with a sloping roof), plans, section, bonding plans for block-courses, details of stairs, fireplaces, window frames, etc., and a full bill of quantities are given.]

CONCRETE ROADS.

Concrete Roads—Second Edition. (Concrete Publications, Ltd.) 5*s*.

[This is the only book published dealing with concrete roads, and it has been very favourably reviewed in the Press. Its chapters include Concrete Roads in England, Scotland, Wales and Ireland, with latest Official Reports as to their Condition, Weight of Traffic, Maintenance Cost, etc.; Concrete Roads in Industrial Works; Concrete Roads in Australia, New Zealand, Canada and America, with latest reports; the Bates Tests of Concrete and other Roads; Mechanical Appliances used in the Construction of Concrete Roads; Concrete Kerbs and Channelling; A suggested form of Specification for Making Concrete Roads; Pavements, Fence Posts, Telegraph and Lamp Posts, etc.; Useful Hints and Data for making Concrete and the Choice of Aggregates, etc. The volume, which contains over 200 pp., is profusely illustrated, and in its compilation the publishers have had the assistance of engineers who have laid successful concrete roads.]

CONCRETE SHIPS.

Seagoing and other Concrete Ships. By N. K. Fougner. (Henry Frowde and Hodder & Stoughton.) 21*s*.

WATERPROOFING CONCRETE.

Impervious Concrete. By H. C. Badder. (Educational Publishing Co.) 12*s*. 6*d*.

Modern Methods of Waterproofing. By Lewis. (McGraw-Hill.) 2*s*. 6*d*.

Waterproofing Engineering. By Joseph Ross. (Chapman & Hall.) 25*s*.

REINFORCED CONCRETE INSPECTION.

Inspectors' Handbook of Reinforced Concrete. By Ballinger. (McGraw-Hill.) 5*s*.

Inspection of Concrete Construction. By Cochran. (McGraw-Hill.) 20*s*.

Concrete Inspection. By Hill. (McGraw-Hill.) 5*s*.

COSTING AND ESTIMATING.

Estimating for Reinforced Concrete. By T. E. Coleman. (Batsford.) 5*s*.

Approximate Estimates, for Architects and Engineers. By T. E. Coleman. (Spon.) 10*s*. 6*d*.

Civil Engineer's Cost Book. By Coleman. (Spon.) 10*s*. 6*d*.

Estimating Building Costs. By C. F. Dingman. (McGraw-Hill.) 12*s*. 6*d*.

Concrete System. By Gilbreth. (McGraw-Hill.) 25*s*.

Handbook of Construction Costs. By H. P. Gillette. (McGraw-Hill.) 30*s*.

Construction Cost Keeping and Management. By H. P. Gillette and R. T. Dana. (McGraw-Hill.) 25*s*.

Modern Management Applied to Construction. By D. J. Hauer. (McGraw-Hill.) 12*s*. 6*d*.

Concrete Costs. By F. W. Taylor and S. E. Thompson. (Chapman & Hall.) 25*s*.

SMALLER USES OF CONCRETE.

Everyday Uses of Portland Cement. (Cement Marketing Co., Ltd.) 7*s*. 6*d*.

Concrete Pottery and Garden Furniture. By R. C. Davison. (Batsford.) 10*s*.

Moulding Concrete Chimneys, Slate and Roof Tiles. By A. A. Houghton. (Spon.) 2*s*. 6*d*.

Moulding and Carving Ornamental Concrete. By A. A. Houghton. (Spon.) 2*s*. 6*d*.

Concrete Monuments, Mausoleums, and Burial Vaults. By A. A. Houghton. (Spon.) 2*s*. 6*d*.

Constructing Concrete Porches. By A. A. Houghton. (Spon.) 2*s*. 6*d*.

Concrete Construction for Rural Communities. By Seaton. (McGraw-Hill.) 11*s*. 3*d*.

Ornamental Cement Work. By O. Wheatley. (Scott, Greenwood.) 6*s*.

[A very useful series of pamphlets dealing with concrete and the smaller uses of the material is issued by the Concrete Utilities Bureau, of 35, Great St. Helen's, E.C.3, from whom they may be obtained (gratis) on application. The series comprises :—(1). Concrete : A Unique Building Material. (2) Concrete : How it is Made. (3) Concrete Tanks and Cisterns. (4) Concrete Paths and Pavements, Kerbs and Gutters. (5) Concrete Fences, Gate-posts and Walls.

(6) Concrete Floors, Feeding Floors and Footpaths. (7) Concrete Poultry Houses and Piggeries. (8) Concrete Farm-buildings. (9) Concrete Troughs and Wells. (10) Concrete Greenhouses, Hot-beds, and Root-cellars. (11) Concrete in the Home. (12) Concrete Blocks : How to Make and Use Them. (13) Concrete : General. (14) Concrete : Its Artistic Possibilities. (15) Concrete Roads Specification. (16) Concrete Products Exhibition.

MINERALOGY.

Silicates in Chemistry and Commerce. By W. Asch and A. B. Searle. (Constable.) 21*s.*

Building Stones and Clays. By E. C. Eckel. (Chapman & Hall.) 15*s.*

Sands and Crushed Rocks. By A. B. Searle. (Henry Frowde and Hodder & Stoughton.) 2 Vols.

The Chemistry and Physics of Clays and Refractory Materials. By A. B. Searle. (Benn Brothers.) 45*s.*

POCKET-BOOKS AND HANDBOOKS.

Structural Engineers' Pocket-Book. By Ewart S. Andrews. (Batsford.) 18*s.*

Pocket-Book of Calculations in Stresses and other Information for Engineers and Architects. By E. M. George. (Spon.) 3*s.* 6*d.*

Engineers' Pocket-Book of Reinforced Concrete. By Heidenreich. (McGraw-Hill.) 15*s.*

Concrete Engineers' Handbook. By Hool and Johnson. (McGraw-Hill.) 30*s.*

Handbook of Building Construction. By G. A. Hool and N. C. Johnson. (McGraw-Hill.) 50*s.*

Bridge and Structural Engineers' Handbook. By Hunter. (Spon.) 10*s.* 6*d.*

Handbook of Formulæ, Tables and Memoranda for Architects, Surveyors, and Draughtsmen and Others engaged in Building. By I. T. Hurst. (Spon.) 8*s.* 6*d.*

Engineers' Year-Book. Edited by H. R. Kempe and W. H. Smith. (Crosby Lockwood.) 30*s.*

Architects' and Builders' Pocket-Book. By the late F. E. Kidder and T. Nolan. (Chapman & Hall.) 35*s.*

Popular Handbook for Cement and Concrete Users. By M. H. Lewis and A. H. Chandler. (Henry Frowde and Hodder & Stoughton.) 18*s.*

Spon's Architects' and Builders' Pocket Price Book. (Spon.) 5*s*.
Spon's Engineers' Tables for Civil and Mechanical Engineers, Builders, etc. (Spon.) 1*s*. 6*d*.
Spon's Practical Builders' Pocket-Book. (Spon.) 8*s*. 6*d*.

CEMENT.

Cement. By B. Blount and W. H. Woodcock. (Longmans, Green.) 18*s*.
Portland Cement : Its Manufacture, Testing and Use. By D. B. Butler. (Spon.) 21*s*.
Treatise on Cement Specifications. By J. Cochran. (Constable.) 7*s*.
Limes and Cements. By Dancaster. (Crosby Lockwood.) 7*s*. 6*d*.
Manufacture of Portland Cement. By A. C. Davis. (John Falconer, Dublin.) 25*s*.
Chemistry and Testing of Cement. By C. H. Desch. (Edward Arnold.) 12*s*.
Cements, Limes and Plasters. By E. C. Eckel. (Chapman & Hall.) 32*s*. 6*d*.
Handbook for Cement Works. By F. B. Gatehouse. (Griffin.) 6*s*.
Experimental Researches upon the Constitution of Hydraulic Mortars. By Le Chatelier. (McGraw-Hill.) 10*s*.
Portland Cement. By Meade. (Chemical Publishing Co., Easton, Pa.)
Cement in Sea-water. By A. Poulsen. (Spon.) 3*s*.
Calcareous Cements. By Redgrave and Spackman. (Griffin.)
Manual of Cement Testing. By W. A. Richards and H. B. North. (Constable.) 8*s*. 6*d*.
Cement, Concrete, and Bricks. By A. B. Searle. (Constable.) 10*s*. 6*d*.
Hydraulic Cement. By F. P. Spalding. (Chapman & Hall.) 10*s*.
Practical Cement Testing. By Taylor. (McGraw-Hill.) 15*s*.
Cement Laboratory Manual. By L. A. Waterbury. (Chapman & Hall.) 5*s*. net.
Manufacture of Portland Cement. By West. (Crosby Lockwood.)

[*Further particulars of some of these books are given in the Catalogue Section, under the heading "Publications."*]

CHAPTER 13.

PROFESSIONAL INSTITUTIONS AND TRADE ASSOCIATIONS.

(*The name of the Secretary is given in brackets.*)

Architects' and Surveyors' Assistants' Professional Union, 36 Victoria St., S.W.1. (John Mitchell.)

Architectural Association, 35 Bedford Sq., W.C.2. (F. R. Yerbury.)

Auctioneers' and Estate Agents' Institute (Incorporated), 34 Russell Sq., W.C.1. (E. H. Blake.)

Berks, Bucks and Oxon Architectural Association, University College, Reading. (Harry Hutt, 164 Friar St., Reading.)

British Engineering Standards Association, 28 Victoria St., S.W.1. (C. Le Maistre.)

Devon & Exeter Architectural Society, Castle House, Exeter. (A. R. Holman.)

Federation of Civil Engineering Contractors, 40 Broadway, S.W.1.

Incorporated Clerks of Works' Association of Great Britain, Carpenters' Hall, E.C.2. (C. W. Denny.)

Institute of Arbitrators, 297 Winchester House, E.C.2. (H. C. Emery.)

Institute of Cost and Works Accountants, 6 Duke St., S.W.1. (A. C. Nicholls.)

Institute of Transport, 15 Savoy St., W.C.2. (A. Winter Gray.)

Institution of Civil Engineers, Gt. George St., S.W.1. (H. H. Jeffcott.)

Institution of Electrical Engineers, Savoy Place, W.C.2. (P. F. Rowell.)

Institution of Engineering Inspection, Palace Chambers, Westminster, S.W.1. (C. J. Wharton.)

Institution of Heating and Ventilating Engineers (Incorporated), 38 Victoria St., S.W.1. (W. G. Hollinworth.)

Institution of Mechanical Engineers, Storey's Gate, S.W.1. (Brig.-General Magnus Mowat.)

Institution of Municipal and County Engineers, 92 Victoria St., S.W.1. (J. W. Dudley Robinson.)

Institution of Royal Engineers, Chatham. (F. E. G. Skey.)

Institution of Sanitary Engineers, 120 Victoria St., S.W.1. (P. N. Hasluck.)

Institution of Structural Engineers, Abbey House, Victoria St., S.W.1. (M. G. Kiddy.)

Junior Institution of Engineers, 39 Victoria St., S.W.1. (Herbert G. Riddle.)

Liverpool Architectural Society, 13 Harrington St., Liverpool. (E. Gee.)

London Builders' Foremen's Association, 48 Bedford Sq., W.C.1. (J. W. Lamden.)

London Master Builders' Association, 48 Bedford Sq., W.C.1. (W. J. Rudderham.)

Manchester Society of Architects, 16 St. Mary's Parsonage, Manchester. (W. S. Beaumont.)

National Federation of Building Trades Employers of Great Britain and Ireland, 48 Bedford Sq., W.C.1. (A. G. White.)

Northamptonshire Association of Architects, 9 Gold St., Northampton. (C. Croft.)

Nottingham and Derby Architectural Society. (H. H. Goodall, 46 Bridlesmith Gate, Nottingham.)

Royal Institute of British Architects, 9 Conduit St., W.1. (Ian MacAlister.)

Royal Institute of the Architects of Ireland, 31 South Frederick St., Dublin. (G. F. Beckett.)

Royal Sanitary Institute and the Parkes Museum of Hygiene, 90 Buckingham Palace Rd., S.W.1. (E. White Wallis.)

Society of Architects, 28 Bedford Sq., W.C.1. (C. McArthur Butler.)

Society of Estate Clerks of Works, 85 Wallwood Rd., Leytonstone. (F. Noble Reavell.)

Society of Technical Engineers, 102 Belgrave Rd., S.W.1. (Richard Hazleton.)

South Wales Institute of Architects, 6 & 7 St. John's Sq., Cardiff. (Ivor P. Jones.)

Surveyors' Institution, 12 Great George St., S.W.1. (A. Goddard.)

Town Planning Institute, 11 Arundel St., W.C.2. (A. R. Potter.)

DIRECTORY

OF THE

CONCRETE INDUSTRY

THE following 58 pages comprise the only directory published in this country dealing solely with the Concrete Industry. No effort has been spared to make it complete, but, as is almost inevitable in the first edition of a directory, it is possible that some names may have been omitted. We should be glad, therefore, if anyone connected with the industry who is not included would send particulars to the Editor, "THE CONCRETE YEAR-BOOK," 35 Great St. Helens, E.C.3, so that they can be included in the 1925 Edition.

Where stated, further particulars of the businesses or products of the firms appearing in the Directory are given in the Catalogue Section.

The whole of the information in this Directory has been supplied by the persons or firms whose names are given.

CONTENTS.

	PAGE
AGGREGATES AND SAND, SUPPLIERS OF	144
ARCHITECTURAL CAST STONE AND PAVING-SLAB MANUFACTURERS	149
ASBESTOS-CEMENT PRODUCTS, MANUFACTURERS OF	151
CEMENT-MAKING MACHINERY, MANUFACTURERS OF	151
CEMENT MANUFACTURERS	152
CEMENT TESTERS	154
CEMENT TESTING, CHEMICALS AND APPARATUS FOR	155
COLOURED CEMENTS	156
COLOURING MATERIALS, MANUFACTURERS OF	156
CONSULTING ENGINEERS	128
CONTRACTORS FOR CONCRETE CONSTRUCTION	157
DESIGNING SPECIALISTS, REINFORCED CONCRETE	143
FLOORING CONTRACTORS, CONCRETE	165
MACHINERY AND PLANT, MANUFACTURERS OF	166
MOULD OIL	170
PAINTS FOR CEMENT	170
PERIODICALS	184
PILING CONTRACTORS AND PILING PLANT	170
PRODUCTS, MANUFACTURERS OF CONCRETE	171
PROOFERS AND HARDENERS, MANUFACTURERS OF	179
PROPAGANDA	180
REINFORCEMENT, MANUFACTURERS OF	181
ROAD ACCESSORIES	184
ROAD CONTRACTORS, CONCRETE	182

* A list of Professional Institutions and Trade Associations connected with the Building and Allied Industries is given on p. 125. A Bibliography of Concrete is given on p. 116.

CONSULTING ENGINEERS WHO SPECIALISE IN REINFORCED CONCRETE.

(*T. = Telephone Number ; T.A. = Telegraphic Address.*)

ABBEY, F., Lic.R.I.B.A. (Abbey & Hanson), 11 Cloth Hall St., Huddersfield. (T., 225.)

ACKERMANN, A. S. E., B.Sc., A.C.G.I., M.Cons.E., A.M.Inst.C.E., M.R.S.I., 17 Victoria St., S.W.1. (T., Vic. 244 ; T.A., Windolite, Vic., London)

ADAM, M. A., B.Sc., F.I.C., A.M.Inst.C.E., A.M.I.E.E., 57 Lincoln's Inn Fields, W.C.2. (T., Holborn 1251.)

ADAMS, HENRY, M.Inst.C.E., M.I.Mech.E., F.S.I., F.R.San.I., F.S.Arc., 60 Queen Victoria St., E.C.4. (T., City 2400.)

ALEXANDER, W., A.M.Inst.C.E., A.M.I.M.E., M.I.E.S., 167 St. Vincent St., Glasgow. (T., Central 122 ; T.A., Alsynder, Glasgow.)

ALLAN, G. J., A.M.Inst.C.E., A.M.Inst.W.E. (Tawse & Allan), 10 Bonaccord Sq., Aberdeen. (T., 1827.)

ALLEN, GEORGE L., M.I.Struct.E., 113 West Regent St., Glasgow. (T., Douglas 3167.)

ALLEN, GEORGE, Jr., M.I.Struct.E., 113 West Regent St., Glasgow. (T., Douglas 3167.)

ALLSEBROOK, V. A., M.I.Struct.E., " Rose and Crown " Hotel, Wisbech. (T., 187.)

ANDERSON, T. S., A.M.Inst.C.E., Royal Insurance Bldgs., Sheffield. (T., 803.)

ANDREWS, C. E. A., B.Sc., A.M.I.Struct.E., 29 Greenhill Rd., Moseley, Birmingham. (T., South 198.)

ANDREWS, E. S., B.Sc., A.M.Inst.C.E., M.I.Struct.E., 201–6 Bank Chambers, 329 High Holborn, W.C.1. (T., Holborn 541.)

AUDEN, A. C., M.Inst.C.E., 5 Victoria St., S.W.1. (T., Vic. 1129.)

BAIGENT, J. W., A.M.I.S.E., 114 Ivy Rd, N.W.2. (T., Vic. 138.)

BAILEY, T. H., M.Inst.C.E., 13 Bennett's Hill, Birmingham. (T., Central 5340.)

Bale, J. H. F., M.I.Mech.E., M.I.Struct.E., 98 Bath Rd., Bridgwater. (T., 56.)

Balfour, David, M.Inst.C.E., F.G.S., F.R.M.S. (David Balfour & Son), 3 St. Nicholas Buildings, Newcastle-upon-Tyne (T., Central 2189); and 5 Mitre Court Chambers, E.C.4 (T., Central 1810).

Ball, E. W., A.M.Inst.C.E., 15 Hoghton St., Southport. (T., 483.)

Barclay, S. F., D.Sc., M.Inst.C.E., M.I.Mech.E., M.I.E.E., Ashdene, Sherwood Av., Sale, Ches. (T., 70.)

Barrington, W., M.Inst.C.E., Clare Chambers, Limerick. (T.A., Barrington, Engineer, Limerick.)

Barron, S. N., B.Sc., A.M.Inst.C.E., Kirkham, Cobham, Kent. (T., Cobham 13.)

Baxter, J. H., A.M.Inst.C.E., A.M.I.E.E., 2 Norfolk St., Hyde. (T., 51 & 11.)

Beckett, W. M., A.M.Inst.C.E., M.S.E., 10 Throgmorton Av., E.C.2. (T., London Wall 319.)

Bell, A. W., A.M.Inst.C.E., F.S.I., F.R.G.S., 22 Ainslie Pl., Edinburgh. (T., Central 3859.)

Bell, G. K., A.M.Inst.C.E., M.Cons.E. (Wilton & Bell), 1 Crosshall St., Liverpool. (T., Central 3257; T.A., Littoral.)

Bell, W. H., A.M.Inst.C.E., 37 Kempford Gdns., S.W.5.

Best, H., M.I.Struct.E., M.C.I., P.A.S.I., M.R.San.I., 87 Church St., Blackpool. (T., 597 & 1432.)

Bicknell, R. H., M.Inst.C.E., 23 Old Queen St., S.W.1. (T., Vic. 858.)

Billington, E. E., M.Sc., 67 Stanley St., Liverpool. (T., Bank 895.

Birkett, R., M.I.Struct.E., Fern Lea, Clyde Rd., West Didsbury, Manchester. (T., Didsbury 277.)

Blaikie, J. R., M.I.E.E., 29 Stanley St., Bedford.

Blake, G. R., A.M.Inst.C.E., 88 Gt. Clyde St., Glasgow. (T., Central 4815.)

Blanchard, L. W., A.M.Inst.C.E., A.M.I.M.E., 88 Longley Rd., Harrow.

Bond, G. C., F.G.S., A.M.Inst.C.E., M.I.Mech.E., 12 Regent St., Nottingham (T., 441.)

Bonnor, G. F., M.Inst.C.E., M.I.E.E., M.I.M.E., Dacre House, Victoria St., S.W.1. (T., Vic. 44.)

Bovey, E. P., & Son, 17–18 Victoria Parade, Torquay. (T., 115.)

Bowles, R. E., B.Sc. (Douglas Leigh & Partners), 100 King St., Manchester. (T., Central 1543.)

Box, E., M.Inst.C.E., 10 Neville St., Newcastle-upon-Tyne. (T., Central 4972.)

Boyes, F. T., A.M.Inst.C.E., 11 Corn Exchange Chambers, Seething Lane, E.C.3. (T., Avenue 1709.)

Bracken, T. W., A.M.Inst.C.E., M.I.M.E., 40 Grey St., Newcastle-upon-Tyne.

Bridges, G. P., A.M.Inst.C.E., A.M.I.Struct.E., A.M.C.I., 20 Mount St., Manchester. (T., City 8200.)

Bridges, Walter, & Co., 37 Parliament St., S.W.1. (T., Vic. 9270.)

Brine, R. H., M.I.Struct.E., M.S.A., M.C.I., 427 Abbey House, Victoria St., S.W.1. (T., Vic. 801.)

Brown, A., M.Inst.C.E., F.S.I., M.Inst.M. & C.E., Glenthorne, 3 Lucknow Av., Nottingham. (T., 102.)

Brown, A. B., M.I.Struct.E., 52 Victoria Bldgs., Victoria St., Manchester. (T., Central 3800.)

Brown, F. W., A.M.Inst.C.E., M.Inst.M. & C.E., 46 Gladstone Park Gdns., N.W.2.

Brown, J., B.Sc., A.M.Inst.C.E., 104 West George St., Glasgow. (T., Douglas 537.)

Brown, W. E. A., F.R.I.B.A., M.I.Struct.E., 9 Regent St., S.W.1. (T., Gerrard 366.)

Bryce, T. H., A.M.Inst.C.E., M.S.E., 25 New Bridge St., Newcastle-upon-Tyne. (T., Central 1520.)

Bunce, E., A.R.I.B.A., M.I.Struct.E., 10 Strathyre Av., S.W.16.

Burch, W., M.Inst.C.E., 55 Wentworth Rd., Harborne, Birmingham.

Busby, Cid, M.I.Struct.E., 296 Vauxhall Bridge Rd., S.W.1. (T., Vic. 2574.)

Butler, D. B., A.M.Inst.C.E., F.C.S., F.S.E., M.I.Struct.E., 6 Earl St., S.W.1. (T., Vic. 5054; T.A., Faija, London.)

Butler, J. D., A.M.Inst.C.E., The Crescent, Holywood, Co. Down.

Bylander, S., 26 Old Burlington St., W.1. (T., Gerrard 5216.)

Carr, W. H. E., A.M.Inst.C.E., 105 New St., Woodbridge, Suffolk. (T., 32.)

Carson, N. B., M.I.Struct.E., 116 Hope St., Glasgow. (T., Central 1146.)

Cartmell, J. M., A.M.I.Mech.E., M.I.Struct.E., M.I.E.S., 8 Gordon St., Glasgow. (T., Central 7444.)

Case, A. H., M.Inst.C.E., Wh.Sc., M.Cons.E., Broad Sanctuary Chambers, S.W.1. (T., Vic. 5541.)

Chapman, J., M.I.Struct.E., 46 King's Rd., S.W.3. (T., Vic. 2590.)

Clark, J. G., M.I.Struct.E., 9 Albert Sq., Manchester. (T., City 5252.)

Clark, J. Percy, F.S.Arc., A.R.C.A., M.I.Struct.E. (Scott & Clark), Regent Chambers, Wednesbury. (T., 26.)

Clarke, A. V., A.M.Inst.C.E., M.I.M.E., A.M.I.E.E., 76 Victoria St., S.W.1. (T., Vic. 6374.)

Clarke, P. J., M.I.Struct.E., M.S.A., 34 Castle St., Liverpool (T., Bank 1252); and 100 King St., Manchester (T., Central 1543).

Cloke, C. J. W., A.M.Inst.C.E., A.M.I.Struct.E., "Elmsted," Neasden Lane, N.W.

Cocking, W. C., M.I.Struct.E., M.J.I.E., 10 New Sq., Lincoln's Inn, W.C.2. (T., Holborn 1677 & 1541.)

Cole, C. S., A.M.Inst.C.E., M.I.Mech.E., Sutton Villa, Sutton Lane, Hounslow. (T., Ealing 293.)

Copland, J. P., M.Inst.C.E., and W. R. Copland, M.Inst.C.E., 146 West. Regent St., Glasgow. (T., Douglas 358; T.A., Copland, Glasgow.)

Corkhill, T. W., M.I.Struct.E., 70 Howard Rd., E.17. (T., Walthamstow 749.)

Cotterell, A. P. I., M.Inst.C.E., F.S.I., M.Inst.M. & Co.E., P.P.Inst.San.E., F.R.S.I., 17 Old Queen St., S.W.1. (T., Vic. 5899.)

Coughlan, P., F.S.I., M.S.A., A.M.I.Struct.E., Clonmel St., Mitchelstown, Co. Cork.

Couper, G. A., M.Sc. (Eng.), A.M.Inst.C.E., 111 The Vale, N.W.11.

Court, H. W., A.M.I.Struct.E., "The Barn," Winn Rd., Grove Park, S.E.

Craig, W. L., B.C.E. (Melb.), A.M.Inst.C.E., 4 Eaglesfield St., Maryport, Cumberland.

Croasdaile, J. E., M.A., M.Inst.C.E., Avenue Chambers, Belfast. (T., 581.)

Crocker, E. G., M.I.Mech.E., M.I.Struct.E., 13 Caxton House, S.W.1. (T., Vic. 5292.)

Crowdy, T., A.M.I.Struct.E., A.M.C.I., A.I.M.M., M.I.S.I., A.M.I.Chem.E., A.M.S.E., F.C.S., M.J.I.E., 13 Clifton Rd., Salisbury.

Cutten, F. A., M.Inst.C.E., 329 High Holborn, W.C.1. (T., Holborn 509.)

Daniel, T. Ll., A.R.I.B.A., M.S.A., M.I.Struct.E., 4 New Sq., W.C.2. (T., City 8022.)

Davey, F. W., A.M.Inst.C.E., 14 Victoria St., S.W.1. (T., Vic. 3931.)

Davidson, D., F.R.S.A., M.I.Struct.E., 47 Park Sq., Leeds.

Davies, J., & Son, A.M.Inst.C.E., M.S.A., M.I.M.E., Cowell House, Llanelly. (T., 367.)

Day, J. P., M.I.Struct.E., 3 Victoria St., S.W.1. (T., Vic. 770.)

Diggle, J., A.M.Inst.C.E., F.G.S., and J. S. Diggle (James Diggle & Son), 14 Brown St., Manchester. (T., Central 3995.)

Dormor, R. D., A.I.S.E., M.I.Struct.E., Abberton Glebe, Colchester, Essex.

Douglas, G. M. H., M.Inst.C.E., 27 Blythswood Sq., Glasgow (T., Douglas 1419); and 26 Frederick St., Edinburgh.

Doyle, E. L., A.M.C.T., A.M.I.S.E., A.M.C.I., A.M.S.A., 39 Esmond Rd., Cheetham Hill, Manchester.

Drake, Norman, A.M.I.Struct.E. (Fredk. Sykes & Drake), 9 Leeds Rd., Bradford. (T., 349.)

Drury, F. E., M.I.Struct.E., F.I.S.E., 46 Moorfield Rd., Pendleton, Manchester. (T., Pendleton 471.)

Duckham, F. W., M.Inst.C.E., 146–147 Grosvenor Rd., S.W.1. (T., Vic. 2945.)

Duff, D. K., A.M.Inst.C.E., 42 Frederick St., Edinburgh. (T., Central 3891.)

Dugdale-Bradley, J. W., M.Inst.C.E., F.G.S., 47 Wheeleys Rd., Birmingham.

Dundas, K., M.C.I., M.Inst.Eng. & Shipbuilders Scot., 224 St. Vincent St., Glasgow. (T., Central 979.)

Edwards, H. F., A.M.Inst.C.E., M.S.W.Inst.E., Guildhall Chambers, Guildhall Pl., Cardiff. (T., 591.)

Egerton, W., M.S.A., F.S.I., M.I.Struct.E., 12 Queen's Rd., Erith. (T., 49.)

Elliott & Brown, Burton Bldgs., Nottingham. (T., 4833.)

Emmott, W., M.Inst.C.E., M.I.E.E., M.Cons.E., 35 Commercial St., Halifax. (T., 785.)

Faber, Oscar, O.B.E., D.Sc., V.P.I.Struct.E., A.M.Inst.C.E., A.M.I.E.E. A.C.G.I., 5 South St., E.C.2. (T., Clerkenwell 4760.)

Fairbank & Son, M.Inst.C.E., M.Inst.W.E., M.Cons.E., Lendal Chambers, York.

Farrow, A. V., A.M.Soc.E., 55 Sommerville Rd., Bristol.

Fawcett, E. Carlon, A.M.Inst.C.E., Loudhams, Amersham, Bucks.

Ferguson, D., A.M.Inst.C.E., 93 Warrender Park Rd., Edinburgh. (T., Central 357.)

Ferguson, R., B.A., B.E., A.M.Inst.C.E., 36 Scottish Provident Bldgs., Belfast. (T., 1059.)

Fergusson, J. C., M.Inst.C.E., 7 Gloucester Sq., Southampton.

Ferneyhough, J., M.I.Struct.E., 569 Gorton Rd., Reddish, Stockport.

Fielding, W. H., M.I.Struct.E., M.S.A., Western Rd., Bletchley, Bucks. (T., 67.)

Finer, H. J., A.M.I.Struct.E., 4 Brook St., St. Paul's, Birmingham. (T., Central 3706.)

Firth, S. E. M., B.Sc. (Eng.) Lond., A.M.Inst.C.E., A.C.G.I., 42 Whitehall Rd., Handsworth, Birmingham.

Fitz-Gibbon, G., M.Inst.C.E., 1 Iddesleigh House, Caxton St., S.W.1. (T., Vic. 33.)

Fleming, S. H., B.A., B.E., A.M.Inst.C.E., 25 Eden Quay, Dublin. (T., 2796.)

Fox, C. H., B.Sc., F.S.I., M.I.Struct.E., 7 Rawson St., Halifax. (T., 486.)

Fox, Sir Douglas, & Partners, M.Inst.C.E., Mem.Amer.Soc.C.E., 38 Bedford Pl., Russell Sq., London, W.C.1. (T., Museum 5940.)

FRECH, S. A., M.Inst.C.E., M.I.Struct.E., Parliament Mansions, Victoria St., S.W.1. (T., Vic. 60.)

FYSON, A., M.Inst.C.E., 89 St. Augustine's Rd., N.W.1.

GALBRAITH, R. F., B.Sc., A.M.I.Struct.E., 63 Waterloo St., S.E.5. (T., Hop 1074.)

GALLOWAY, J., M.I.Struct.E., A.M.I.Mech.E., 156 Ayres Rd., Old Trafford, Manchester. (T., Trafford Park 161.)

GAMBLE, J. C., M.R.I.A.I., M.I.Struct.E., King's Hill, Galway, Ireland.

GAMBLE, S. G., A.M.Inst.C.E., F.S.I., 8 Waterloo Pl., S.W.1. (T., Regent 4800.)

GARDNER, G. A., M.Soc.C.E. (France), M.Math.Assn., M.I.Struct.E., 40 Oakfield Rd., Old Southgate, N.14.

GEDYE, N. G., M.Inst.C.E., 5 Victoria St., S.W.1. (T., Vic. 5950.)

GEEN, BURNARD, M.Inst.C.E., 122 Victoria St., S.W.1. (T., Vic. 2258.)

GIBB & SMITH, Borough Chambers, Neath. (T., 329.)

GIBB, SIR ALEXANDER, & PARTNERS, Queen Anne's Lodge, S.W.1. (T., Vic. 1937.)

GILBERT, W., M.Inst.C.E., 31 Criffel Av., S.W. (T., Streatham 3077.)

GLOVER, J., M.A. (Cantab.), M.Inst.C.E., Lowton House, Lowton, Lancs.

GLOVER, S., M.Inst.C.E., Olive Mount, Grosvenor Rd., St. Helens. (T., 96.)

GOLDING, H. H., A.R.I.B.A., M.I.Struct.E., 12 Casewick Rd., S.E.27. (T., Streatham 3574.)

GORDON, A. E., M.I.Mech.E., M.I.Struct.E., "Holmdale," Queen's Rd., Sketty, Swansea.

GOULDING, W. W., P.A.S.I., M.I.Struct.E., 8 Marshall Rd., Levenshulme, Manchester.

GRANT, J. W., A.M.I.Struct.E., A.F.P.W.Inst., 10 Kelly St., Greenock.

GRANTHAM, G. J., A.M.Inst.C.E., A.M.I.Struct.E., "Hest Bank," Leighton Rd., Old Trafford, Manchester.

GRAY, C. S., B.Sc., A.M.I.Struct.E., 6 Norris Rd., Reading.

GREEN, W. A., M.A., B.Sc., A.M.Inst.C.E., M.I.Struct.E., 3 King's Av., W.5. (T., Kens. 1049.)

GREENFIELD, T., A.M.I.Struct.E., M.S.A., Easebourne, Midhurst, Sussex.

GRIFFITH, P., M.Inst.C.E., M.I.Mech.E., F.G.S., M.I.WaterE., 20 Victoria St., S.W.1. (T., Vic. 5913.)

GRUNSPAN, A. S., B.Sc., A.C.G.I., A.M.Inst.C.E., "Abbey House," Victoria St., S.W.1. (T., Vic. 4746.)

GUÉRITTE, T. J., M.Soc.C.E. (France), F.S.E., M.I.Struct.E., 38 Victoria St., S.W.1 (T., Vic. 6506.)

HAISTE, J. H., M.Inst.C.E., Union Bank Chambers, Trinity House Lane, Hull (T., Corpn. 1138) ; and 26 Victoria St., Grimsby (T., 2187).

HANSON, J. H., M.Inst.C.E., P.P.S.I. (Abbey & Hanson), 11 Cloth Hall St., Huddersfield. (T., 225.)

HARMAN, E. A., M.Inst.C.E., 36 De Grey St., Hull. (T., Central 7828.)

HARRIS, H. E., A.M.I.Mech.E., M.Inst.Met., M.I.Struct.E., 22 Belgrave Ter., Newcastle-upon-Tyne. (T., City 5001.)

HARRISON, B. A., B.Eng., A.M.Inst.C.E., 26 Hard Lane, St. Helens.

HARRISON, J. F., M.Inst.C.E., 50 John St., Glasgow.

HART, V., "Westmere," Western Rd., Cork.

HARTLEY, A. C., B.Sc., M.Inst.C.E., A.M.I.M.E., 23 Queen Anne's Gate, S.W.1. (T., Vic. 2794.)

HAUGHTON, H., M.I.Struct.E., 45 Strathbrook Rd., Streatham, S.W.16.

HAY, S. G., A.M.Inst.C.E., 83 Blackfriars Rd., Salford, Manchester. (T., City 3629.)

HEALEY, W., B.Sc., A.M.Inst.C.E., A.M.I.M.E., F.R.S.A., 15 Holker St., Keighley. (T., 827.)

HEDGES, KILLINGWORTH, M.Inst.C.E., 10 Cranley Pl., South Kensington, S.W.1. (T., Kens. 6703.)

HENDERSON & NICOL, 21, Bridge St., Aberdeen. (T., 1510.)

HENRY, T. W., F.S.Arc., M.C.I., M.I.Struct.E., 16 Donegall Sq. South, Belfast. (T., Belfast 4156.)

HENRY, W. T., M.I.Struct.E., A.R.S.I., 10A Wemyss Rd., Blackheath, S.E.

HERRING, W. R., M.Inst.C.E., 4 Arundel St., W.C.2. (T., City 8067.)

HIBBINS, W. G., A.M.Inst.C.E., 56 Endcliffe Rise Rd., Sheffield.

HICKSON, C., M.S.A., M.I.Struct.E. (Stocks, Sykes & Hickson), 4 St. Peter's St., Huddersfield. (T., 2507.)

HIGGINS, E., A.M.C.I., A.M.I.Struct.E., 306 School Rd., Crookes, Sheffield.

HIGHFIELD, J. S., A.K.C., M.Inst.C.E., M.I.E.E., and W. E. HIGHFIELD, M.I.E.E., 36 Victoria St., S.W.1. (T., Vic. 2489.)

HILEY, B. A. E., A.M.Inst.C.E., 119 Connaught Rd., Cardiff. (T., 3088.)

HILL, C. W., A.M.Inst.C.E., 23 Old Queen St., S.W.1. (T., Vic. 3411.)

HILL, H. ASHTON, M.Inst.C.E., 3 Hermitage Rd., Edgbaston, Birmingham. (T., 40.)

HILL, J. R., A.M.Inst.C.E., A.M.I.Struct.E., "Rushmere," Orley Farm Rd., Harrow-on-the-Hill.

HILLS, O. C., F.R.I.B.A., M.I.Struct.E., 60 Haymarket, S.W.1. (T., Gerrard 4553.)

HITCHENS, A. P., B.Eng., A.M.Inst.C.E., M.I.Struct.E., 8 Queen's Rd., Great Crosby, Liverpool.

HOARE, E. S., A.M.Inst.C.E., B.Sc., A.C.G.I., 39 Broad St., Bristol. (T., 5435.)

HODSMAN, G. W., A.M.Inst.C.E., Heatonroyd, Wakefield Rd., Dewsbury.

HONEYSETT, A., A.M.Inst.C.E., F.R.S.A., 124 Victoria St., S.W.1. (T., Vic. 9554.)

HOULDSWORTH, A. F., M.I.Struct.E., P.A.S.I., 20 Savile St., Hull. (T., 2112.)

HUMPHREYS, HOWARD, & SONS, M.Inst.C.E., M.Inst.M.E., M.A., M.Sc., 28 Victoria St., S.W.1. (T., Vic. 5228.)

HURSE, A. E., M.Inst.C.E., M.R.S.I., 27 Clarence Pl., Gravesend.

HURST, B. L., M.Inst.C.E., M.I.Mech.E., M.I.Struct.E., Craigs Court House, Whitehall, S.W. (T., Central 3282.)

HUTTON, C. H., M.Inst.C.E., Great Witley, Worcester.

INGHAM, D. P., M.Soc.C.E. (France), M.S.E., Royal Exchange, Middlesbrough. (T., 269.)

INMAN, W. C., P.A.S.I., M.I.Struct.E., 6 New Sq., W.C.2. (T., Holborn 5086.)

JAMES, F. L., A.M.Inst.C.E., Oak House, Heworth, York.

JENKIN, E., M.I.Struct.E., Bridge Chambers, Bridge St., Exeter; and Morton Rd., Exmouth.

JOHNSON, H. J., F.S.I., M.I.Struct.E., 21 Queen Anne's Gate, S.W.1. (T., Vic. 1693.)

JONES, R. A., A.M.Inst.C.E., M.I.Mech.E., M.I.N.A., Chappell's Chambers, Castle St., Swansea.

JONES, W., A.M.Inst.C.E., Trefgarnedd, Meirion Gdns., Colwyn Bay.

KAYLOR, E., A.M.Inst.C.E., M.Soc.C.E. (France), 30 Spring Gdns., Manchester. (T., Central 5393.)

KEAY, W., M.Inst.C.E., 6 Millstone Lane, Leicester. (T., Central 25.)

KELL, A. T. B., M.I.Struct.E., 17 Percy St., Tottenham Court Rd., W.1. (T., Mus. 7773.)

KENT, H. V., M.Inst.C.E., M.Inst.R.E., M.Am.Soc.C.E., 20 Castle St., Dover. (T., 242.)

KENWORTHY, G., A.M.Inst.C.E., 3 Victoria St., S.W.1; and Bank Chambers, Norwich (T., Norwich 780).

KERSEY, A. H., F.R.I.B.A., F.S.I., 91 Moorgate, E.C. (T., Central 4412.)

KERSEY, A. T. J., A.R.C.Sc., Wh.Ex., M.I.Mech.E., 6 Sorrel Bank, Eccles Old Rd., Pendleton, Manchester. (T., Pendleton 448.)

KERSHAW, L. W., B.Sc. (Eng.), A.M.Inst.C.E., F.G.S., The Elms, Loughborough (T., 675 & 676).

KIDD, T., A.M.Inst.C.E., 2 Belmont St. and 40 Eureka Rd., Swadlincote.

KINCAID, WALLER, MANVILLE & DAWSON, St. Stephen's House, Victoria Embankment, Westminster, S.W.1. (T., Vic. 4311.)

KINGWELL, A. E., F.S.A., A.I.Struct.E., 103 & 104 Cheapside, E.C.2. (T., Barnet 123.)

KIRKUP, P., M.Inst.C.E., M.I.M.E., "Briermede," Low Fell, Gateshead-upon-Tyne. (T., 545.)

KITCHIN, J. W., M.Inst.C.E., M.Am.Soc.C.E., 715 Salisbury House, London Wall, E.C.2. (T., London Wall 4270.)

KNIGHT, H. V., M.I.Struct.E., M.C.I., Royal Liver Bldg., Liverpool. (T., Bank 3879.)

KNIPE and PARTNERS, 87 Victoria St., S.W.1. (T., Vic. 4322.)

KNOTT, F., 23 Queen Anne's Gate, S.W.1. (T., Vic. 2794.)

LAING, W. A. B., M.Inst.C.E., 27 Blythswood Sq., Glasgow (T., Douglas 1419); and 26 Frederick St., Edinburgh.

LAKEMAN, ALBERT, M.S.A., M.I.Struct.E., 172 Orphanage Rd., Erdington, Birmingham. (T., Erdington 331.)

LANGDON, W., M.Inst.C.E., M.I.M.E., Kensey St. Stephens, Launceston, Cornwall.

LEE, R. H. L., A.M.Inst.C.E., A.I.M.M., 28 Hatton Gdn., E.C.1. (T., Holborn 1273.)

LEIGH, W., A.M.Inst.C.E., A.M.I.Mech.E., A.M.I.T., 21 Cannon St., Manchester. (T., Central 3916.)

LEITCH, A., M.I.Mech.E., M.I.Struct.E., 18 Victoria St., S.W.1 (T., Vic. 6474); and 30 Buchanan St., Glasgow (T., Central 7526).

LEWIS, D. I., F.S.A., M.I.Struct.E., A.M.T.P.I., M.R.San.I., 4 Spencer Rd., Newport, Mon.

LEWIS, H. M., A.M.Inst.C.E., A.R.I.B.A., "Sunnyside," Pontypridd, Glamorgan. (T., 190.)

LEWIS, H. M., A.R.I.B.A., Wokingham.

LIBBIS, G. H. A.M.Inst.C.E. Sweetdown, Hockley Rd., Rayleigh.

LINTON, W., A.M.Inst.C.E., 133A George St., Edinburgh. (T., Central 6857.)

LIVERSAGE, J. N., A.M.I.Struct.E., M.R.San.I., 24 Crowthorn Rd., Ashton-under-Lyne, nr. Manchester.

LORD, J., M.Inst.C.E., 17 Crossley St., Halifax. (T., 75.)

LUKE, A. W., M.Inst.C.E., M.I.Struct.E., M.I.P.A., 15 Crown Ter., Dowanhill, Glasgow. (T., Western 4160.)

LYELL, D., M.Inst.C.E., F.R.S.A., 26 Victoria St., S.W.1. (T., Vic. 4945.)

MacDougall, A., A.M.Inst.C.E., A.M.I.P.T., 28 Heathview Rd., Thornton Heath, S.W. (T., Hop 4321.)

McGilvray, J. A., A.M.I.E.S., M.C.I., M.I.Struct.E., 144 St. Vincent St., Glasgow. (T., Central 3407 & Western 264.)

McGlashan, G. D., M.Inst.C.E., 3 St. Nicholas Bldgs., Newcastle-upon-Tyne, (T., Central 536.)

McIlveen, A., M.R.I.A.I., A.M.Inst.C.E., 36 Scottish Provident Bldgs., Belfast. (T., 1059.)

Macklow-Smith, A., B.Sc., A.M.Inst.C.E., A.M.I.M.E., Queen Anne's Chambers, S.W.1. (T., Vic. 5369.)

McLean, G., A.R.I.B.A. (Richards, McLean & Williams), 5 Dumfries Pl., Cardiff. (T., 4114.)

MacPhail, W. J., A.M.Inst.C.E., A.M.A.C.E., 103 Delhi St., Belfast. (T., 4544.)

Maltby, F. T., A.M.Inst.C.E., M.S.A., South St., Dorchester. (T., 76.)

Markham, C. C., A.M.Inst.C.E., Limekilns, Co. Fife.

Markham, J. H., A.R.I.B.A., M.I.Struct.E., "Elmside," Marlborough Hill, Harrow. (T., 107.)

Marks, Sir G. Croydon, M.I.M.E., A.M.Inst.C.E., 58 Lincoln's Inn Fields, W.C.2. (T., Central 3415.)

Marsh, G. S., A.M.Inst.C.E., 88 Abingdon Rd., W.8.

Marshall, A. E., M.I.Struct.E., 49 Kingswood Rd., Goodmayes, Essex.

Mason, F. B., M.I.Struct.E., 104 Victoria St., S.W.1. (T., Vic. 541.)

Massie, F., M.Inst.C.E., F.S.I., Tetley House, Wakefield. (T., 96.)

Mather, T. Brewer, M.Inst.C.E., 33 High Bridge, Newcastle-upon-Tyne. (T., Central 801.)

Maxted, G. V., M.Inst.C.E., 23 Queen Anne's Gate, S.W.1. (T., Vic. 2794.)

May, Frank, A.M.Inst.C.E., 54 Queen's Rd., Monkseaton, Northumberland.

Meik, C. S., & Buchanan, MM.Inst.C.E., 16 Victoria St., S.W.1. (T., Vic. 370.)

Meston, A. C., Lic.R.I.B.A., M.I.Struct.E., 10 New Sq., Lincoln's Inn, W.C.2. (T., Holborn 1677.)

Miller, Thos., Son & Clarke, 9 Thoroughfare, Ipswich. (T., 328.)

Milliken, M. J., A.M.Inst.C.E., 94 Alexandra Park Av., Belfast.

Mitchell, A. C., M.Inst.C.E., Royal Exchange, Middlesbrough. (T., 896.)

Mitchell, G. A., A.R.I.B.A., M.I.Struct.E., 37 Castlebar Park, W.5. (T., Ealing 1153.)

Mobbs, S. K., A.M.Inst.C.E., M.I.Struct.E., 42 Alfriston Rd., S.W.11.

Moncrieff, J. Mitchell, & Partners, M.Inst.C.E., 57 Victoria St., S.W.1 (T., Vic. 1387); and Pearl Bldgs., Newcastle-upon-Tyne (T., Central 2644).

Money-Kent, J. M. V., M.Inst.C.E., M.I.Mech.E., 121 Victoria St., S.W.1. (T., Vic. 1156.)

Moore, J., A.M.Inst.C.E., M.S.A., M.Inst.C.E.I., 14 Lower Sackville St., Dublin. (T., 4410.)

Muirhead, T., B.Sc., A.M.Inst.C.E., Palace Chambers, S.W.1. (T., Vic. 1958.)

Murgatroyd, N. B., A.M.I.S.E., F.B.Soc.E., A.M.C.I., 10 West Rd., Prestwich, Manchester.

Murphy, E. M., A.M.Inst.C.E., 27, Molesworth St., Dublin. (T., 97.)

Ness, G., M.I.Struct.E., "Stonelea," Harlow Hill, Otley Rd., Harrogate. (T., 178.)

Newborn, C. R., Lic.R.I.B.A., F.S.I., M.I.Struct.E., 6 New Sq., W.C.2. (T., Holborn 5086.)

Newson, C., M.S.A., M.I.Struct.E., "Jevington," Polegate, Sussex.

Nicholl, J. C., A.M.Inst.C.E. (Nicholl & Nunn), 62, King's Arcade, Bradford, (T., 3929.)

Nixon, J., A.M.I.Struct.E., 103 John St., Workington.

Nunn, H. V., A.M.I.Mech.E. (Nicholl & Nunn), 62 King's Arcade, Bradford. (T., 3929.)

Oakey, J. J. L., F.B.I.C.C., A.M.S.E., A.M.Struct.E., A.M.C.I., 40 Brunswick St., Cheltenham.

Orrell, J. A., A.M.Inst.C.E., A.M.Amer.Soc.C.E., 12 Spring Gdns., Manchester. (T., City 1956.)

Osborne, R., A.M.I.Struct.E., The Limes, Chellaston, Derby.

Ough, A. H., M.Inst,.C.E., F.R.I.B.A., Stanmore, Dawlish.

Owens, J. S., B.A., A.M.Inst.C.E., F.R.S.I., F.G.S., F.R.G.S., 47 Victoria St., S.W.1. (T., Vic. 4158.)

Pace, C. L., M.S.A., A.R.I.B.A., M.I.Struct.E., 25 St. George's Sq., Regent's Park, N.W.1.

Pain, C., A.M.Inst.C.E., 17 Victoria St., S.W.1. (T., Vic. 5125.)

Palmer, W. E. K., F.S.I., A.R.I.B.A., M.C.I., 7 Duke St., W.C.2. (T., Regent 776.)

Parker, J. E., A.M.Inst.C.E., M.R.S.I., M.I.M. & C.E., Post Office Chambers, St. Nicholas Sq., Newcastle-upon-Tyne. (T., Central 4979.)

Parr, S. G., Lic.R.I.B.A., F.S.I., New Broad St. House, E.C.2. (T., Central 3788.)

Parr-Head, A. S., A.M.I.Struct.E., A.M.I.San.E., 3 St. George's Av., W.5, (T., Ealing 750.)

Payne, C. S., B.Sc., M.I.Struct.E., Imber Court, East Molesey, Surrey. (T., Esher 341.)

Pearson, F. J., A.M.I.Struct.E., 1 The Crescent, Anson Estate, Manchester.

Pearson, J. M., L.A., F.S.I., A.M.Inst.C.E., 51 John Finnie St., Kilmarnock. (T., 225.)

Perkins, W. J., A.M.Inst.C.E., M.I.Mech.E., 26 Victoria St., S.W.1. (T., Vic. 1872.)

Pimm, Gower, M.I.Struct.E., A.M.Inst.C.E., M.Inst.W.E., 72 Queen Sq., Bristol. (T., 2820; T.A., Arduavinc, Bristol.)

Pirie, J. S., M.Inst.C.E., 135 George St., Edinburgh. (T., Central 2273.)

Pitman, A. J., M.B.E., M.I.Struct.E., 8 Alexandra Mansions, Prince of Wales Rd., Norwich.

Popplewell, W. C., M.Sc., A.M.Inst.C.E., 60 Parsonage Rd., Withington, Manchester.

Prescott, Sir W., M.Inst.C.E., M.I.M.E., Allington House, Tottenham, N.17. (T., Tott. 1913.)

Radcliffe, F., M.I.Struct.E., 190 Trinity St., Huddersfield.

Rawlins, G. B., B.Sc., A.M.Inst.C.E. (Edwards & Shaw), 105 Colmore Row, Birmingham. (T., Central 6810.)

Reade, J. F., A.M.Inst.C.E., M.I.C.E.I., 29 Barronstrand St., Waterford.

Rees, F. W., M.S.A., M.I.Struct.E., F.I.Ar., M.C.I., 44 Park Lane, Croydon. (T., 1030.)

Remington, G., M.Inst.C.E., 13 Eaton Crescent, Swansea.

Richards, S. L., A.M.Inst.C.E. (Richards, McLean & Williams), 5 Dumfries Pl., Cardiff. (T., 4114.)

Ridley, M. Noel, M.Inst.C.E., M.C.I., 80 Harold Ter., Leeds. (T., 20196.)

Rigby, J. S., F.C.S., M.Inst.C.E., 9–11 Hilbre St., Liverpool. (T., Royal 1195.)

Ritchie, H. C., M.I.Struct.E., 708 Royal Liver Bldg., Liverpool. (T., Bank 3879.)

Ritson, T. N., A.M.Inst.C.E., "Glendene," Summersdale, Chichester. (T. Lavant 2.)

Roberts, D. H., M.Inst.C.E., Park St., Wombwell. (T., 20.)

Roberts, J. J., A.M.Inst.C.E., A.M.I.Mech.E., A.M.I.E.E., Rose Cottage, Compton, Wolverhampton.

Robertson, J., A.M.Inst.C.E., 123 London Rd., High Wycombe. (T., 184.)

Robinson, H. St. G., M.Inst.S.E., M.C.I., 117 Victoria St., S.W.1. (T., Vic. 8573.)

Rogers, A. B. C., M.Inst.C.E., 32 St. James' Sq., S.W.1. (T., Regent 5133.)

Rothwell, W. E., M.Inst.C.E., 33 Palatine Bldgs., 76 Victoria St., Manchester. (T., City 9186.)

Ruane, A. A., A.M.I.Struct.E., F.R.S.A., 347 George Rd., Erdington, Birmingham.

SAINSBURY, F. G., M.S.A., M.I.Struct.E., M.C.I., 154 Friar St., Reading.

SALKELD, F. J., A.M.I.Struct.E., A.M.I.Chem.E., A.M.S.E., "Riversdale," Trentham St., Runcorn, Ches.

SALKIELD, T., M.Inst.C.E., F.R.S.I., M.Inst.T., 45 Thurlby Rd., S.E.27.

SARGEANT, E. F., A.M.Inst.C.E., Skelton, York.

SAVAGE, W., Wh.Sc., A.M.Inst.C.E., M.I.S.I., 77 Beech St., Crewe.

SCHOFIELD, R. W., A.M.I.Struct.E., A.M.S.E., 16 Alfriston Rd., S.W.11.

SCOTT, ALBAN, F.S.Arch., F.I.Struct.E., M.I.Metals, M.R.S.I., 13 Old Sq., W.C.2. (T., Central 6804.)

SCOTT, W. A., M.I.Struct.E., "Mylapore," Stanley Rd., West Croydon.

SEARLE, A. B., 440 Glossop Rd., Sheffield. (T., West 178.)

SEARLES-WOOD, H. D., F.R.I.B.A., F.R.San.I., M.I.Struct.E., Painters' Hall Chambers, 8 Little Trinity Lane, E.C.4. (T., Central 2365.)

SELBY, A., M.I.S.E., 26 Rosslyn Rd., Barking, E.

SHADBOLT, B., Lic.R.I.B.A., M.I.S.E., Victoria Rd., Horley, Surrey.

SIMPSON, W., M.Inst.C.E., M.I.Mech.E., M.I.Struct.E., Tavistock House, Borough Rd., Sunderland. (T., 1610.)

SMART, P., A.M.Inst.C.E., M.Inst.M. & C.E., 7 Anderton Park Rd., Moseley, Birmingham. (T., Vic. 3.)

SMITH, G., B.Sc., M.I.Struct.E., 14 Outram Rd., Addiscombe, Surrey.

SMITH, G. W., M.S.A., M.I.Struct.E., 6 New Sq., W.C.2. (T., Holborn 5086.)

SMITH, W. H., M.I.Struct.E., M.I.A.E., The Cottage, Imber Court, East Molesey, Surrey. (T., Esher 341.)

SPLITTER, B., A.M.Inst.C.E., A.M.I.Mech.E., A.M.I.Aut.E., A.C.G.I., "The Limes," Woodberry Down, N.4. (T., Dalston 1869.)

STAINSBY, W., B.Sc., A.M.Inst.C.E., A.M.I.M.E., 41 University Rd., Leeds.

STARKEY, L. J., A.M.I.Struct.E., Pinner Hill Rd., Pinner. (T., 34.)

STEDMAN, A. G., M.S.E., M.I.Struct.E., M.C.I., 317 High Holborn, W.C. (T., Holborn 1875.)

STENT, D. H., A.M.Inst.C.E., M.I.E., 6E Hyde Park Mansions, N.W.1. (T., Padd. 5367.)

STEVENS, T., M.Inst.C.E., M.I.Min.E., M.I.E.E., A.A.I.E.E., 50 Lincoln's Inn Fields, W.C.2. (T., Holborn 5250.)

STEWART, J. E., M.Inst.C.E., M.I.E.E., Castle Bldgs., Llanelly. (T., 426.)

STROYER, R. N., M.I.Mech.E., 4 Westminster Palace Gdns., S.W.1. (T., Vic. 8186.)

SUFFIELD, F. W., A.M.I.Mech.E., M.I.Struct.E., 57 Colmore Row, Birmingham. (T., Central 5747; T.A., Steelwork, Birmingham.)

SWAINSON, J. H., A.M.Inst.C.E., M.R.San.I., 1 Hill St., Wrexham.

SWARBRICK, JOSEPH, M.Inst.C.E., F.R.I.B.A., and JOHN SWARBRICK, F.R.I.B.A., M.I.Struct.E., 30 St. Ann St., Manchester. (T., Central 2886.)

Taylor, B., A.M.I.M.E., M.I.Struct.E., Rostern Hill Top Av., Cheadle Hulme, Ches. (T., Cheadle Hulme 40.)

Taylor, W. J., A.R.I.B.A., A.M.I.Struct.E., 28 Queen's Gate, Inverness. (T., 314.)

Taylor & Wallin, 47 Pilgrim St., Newcastle-upon-Tyne. (T., Central 388.)

Thieme, H. C. A., B.Sc., A.C.G.I., A.M.Inst.C.E., A.M.I.Mech.E., 20 Sandford Rd., Ranelagh, Dublin. (T., Kingstown 14.)

Thomson, J., A.M.Inst.C.E., M.R.I.P.H., 55 Morningside Park, Edinburgh. (T., Central 564.)

Thorpe, W. H., A.M.Inst.C.E., 12 Buckingham St., W.C.2.

Tierney, D. J., B.A., B.E., A.M.Inst.C.E., 16 Cook St., Cork. (T., 958.)

Tinslay, T. P., F.S.I., Lic.R.I.B.A., M.I.Struct.E., 26 Wilfred St., S.W.1 (T., Vic. 5816.)

Trotman, G., M.S.A., F.I.S.E., M.C.I., 32A Camberwell Grove, S.E.5.

Turnbull, N. K., Wh.Sc., A.M.Inst.C.E., M.I.S.I., Pentwyn House, Ebbw Vale.

Turner, E. C., A.M.I.Struct.E., 27 Maldon Rd., W.3.

Turner, J. W., A.M.I.Struct.E., A.M.C.I., Sydenham Rd., North Croydon. (T., Thornton Heath 1703.)

Twentyman, J. R., M.Inst.C.E., F.R.S.A., Kirby Misperton Hall, Pickering. (T., Pickering 24.)

Twinberrow, J. W., M.Inst.C.E., Dursley, Glos.

Wade, F. R., M.I.M.E., M.I.E.I., M.I.A.E., M.C.I., 1 Dr. Johnson's Bldgs., Inner Temple, E.C. (T., City 8068.)

Walker, E. G., A.M.Inst.C.E., M.I.Mech.E., M.Am.Soc.C.E., 23 Queen Anne's Gate, S.W.1. (T., Vic. 529.)

Walker, H., M.Inst.C.E., F.S.I., 408 Mansfield Rd., Nottingham. (T., 4344.)

Walker, W. G., A.M.Inst.C.E., M.I.Mech.E., Emery Hill St., S.W.1. (T., Vic. 1622.)

Wall, T. F., D.Sc., D.Eng., A.M.Inst.C.E., A.M.I.E.E., Carr Bank House, Fulwood, Sheffield. (T., 4705.)

Wallis, T., F.S.Arc., M.I.Struct.E., F.I.Arc., 29 Roland Gdns., S. Kensington, S.W. (T., Kens. 3816.)

Ware, E., M.I.Struct.E., F.S.I., F.I.Arc., 43 Imperial Bldgs., Exchange St. East, Liverpool. (T., Central 3939.)

Watson, G., M.Inst.C.E., M.I.M.E., Walter House, Bedford St., W.C.1. (T., Gerrard 1840.)

Watson, W. H., F.S.Arc., Lic.R.I.B.A., M.I.Struct.E., Barstow Sq., Wakefield. (T., 166.)

Webb, A., A.M.I.Struct.E., Spa Vale, Caistor, Lincs. (T., Warsop 24.)

Webb, C. H., B.Sc., A.M.Inst.C.E., M.I.W.E., 137 Gold Croft, Yeovil, Somerset.

Webber, W. H., M.I.Struct.E., 33 Furnival St., E.C.4. (T., Holborn 194.)

Weekes, R. W., M.I.E.E., A.M.Inst.C.E., Maxwell House, Arundel St., W.C.2. (T., Central 11488.)

Weir, W. P., M.Inst.C.E., 121 West Regent St., Glasgow.

Weldon, H. N., A.M.Inst.C.E., 23 Westminster Palace Gdns., S.W.1. (T., Vic. 1919.)

Whincop, W. G., A.M.I.Struct.E., A.R.I.B.A., M.R.San.I., 14 Westholm Hampstead Garden Suburb, N.W.11.

Whitaker, J., A.M.Inst.C.E., 3 Cooper St., Manchester. (T., Central 5377 ; T.A., Granary, Manchester.)

Whitaker, Hall & Owen, M.I.Struct.E., 1 Gresham Bldgs., Basinghall St., E.C. (T., London Wall 3621.)

White, S. H., A.M.Inst.C.E., M.I.Struct.E., M.A.A., 9 Victoria St., S.W.1. (T., Vic. 5100.)

Williams, G. P., M.Inst.C.E., 14 Victoria St., S.W.1. (T., Vic. 1450.)

Wilson, A., M.Inst.C.E., F.R.S.E., 51 Queen St., Edinburgh. (T., 1594.)

Wilson, J. S., A.C.G.I., A.M.Inst.C.E., 181 Queen Victoria St., E.C.4. (T., Central 2876.)

Wilton, T. R., M.A., M.Inst.C.E., M.Cons.E. (Wilton & Bell), 1 Crosshall St., Liverpool. (T., Central 3257 ; T.A., Littoral, Liverpool.)

Winn, S. G., A.M.Inst.C.E., Wh.Sc., 83 Osborne Rd., Romford.

Womersley, W. D., A.M.Inst.C.E., A.M.I.Mech.E., 106 Huntingdon Rd., Cambridge.

Wood, C. R. J., A.M.Inst.C.E., 38 Victoria St., S.W.1. (T., Vic. 6506.)

Woodfield, C. H., M.I.Mech.E., M.I.Struct.E., 6 Queen Anne's Gate, S.W.1. (T., Western 173.)

Wrench, F. H., A.M.Inst.C.E., Lic.R.I.B.A., 217 Upperthorpe, Sheffield. (T., 1398.)

Wyllie, J. B., A.M.Inst.C.E. (James B. Wyllie & Son), 219 St. Vincent St., Glasgow. (T., Central 5804.)

Yearsley, H. A., M.I.Struct.E., 25 Market St., Manchester. (T., City 3132.)

Yewdall, P., A.M.Inst.C.E., Crown Point Bridge, Leeds. (T., 26232.)

Young, A. G., M.I.Struct.E., A.M.I.Mech.E., 6 Queen Anne's Gate, S.W.1. (T., Vic. 876.)

Young, D. S., M.I.Struct.E., M.I.Mech.E., 6 Queen Anne's Gate, S.W.1. (T. Vic. 660.)

REINFORCED CONCRETE DESIGNING SPECIALISTS.

(*The firms marked with an asterisk are also Contractors.*)

ANGLO-DANISH CONCRETE CONSTRUCTION CO., LTD., 7 & 8 Norfolk St., W.C.2. T., Central 6138; T.A., Anglodany, Estrand, London.* (*See p.* 225.)

BAIN & BROWN, LTD., 236 Leith Walk, Leith. T., 346.* (*See p.* 226.)

BIRMINGHAM CONCRETE STEEL CO., 125 Edmund St., Birmingham. T., Central 3273. (*See p.* 228.)

CHIMNEYS, LTD., 47 Victoria St., S.W.1. T., Vic. 4700; T.A., Stablochim, Vic, London.*

CHRISTIANI & NIELSEN, 72–74 Victoria St., S.W.1. T., Vic. 3565–6; T.A., Reconcret, Vic, London.*

COIGNET, EDMOND, LTD., 125 Gower St., W.C.1. T., Museum 6497; T.A., Tengioc, Eusroad, London. (*See p.* 229.)

CONSIDÈRE CONSTRUCTIONS, LTD., 72 Victoria St., S.W.1. T., Vic. 3033; T.A., Spiralette, London.

EVANS BROS., Riddings, Alfreton, Derbyshire. T., Riddings 3. T.A., Evans Bros., Riddings.* (*See p.* 291.)

HOLST, K., & Co., 1 Victoria St., S.W.1. T., Vic. 4234; T.A., Ferrolst, Sowest, London.* (*See p.* 231.)

INDENTED BAR & CONCRETE ENGINEERING CO., LTD., Queen Anne's Chbrs., S.W.1. T., Vic. 1642; T.A., Patinbar, Parl, London.

INDUSTRIAL CONSTRUCTIONS, LTD., 44 Grosvenor Place, S.W.1. T., Vic. 6590; T.A., Refcretcon, Phone, London.* (*See pp.* 232–3.)

JOHNSON'S REINFORCED CONCRETE ENGINEERING CO., LTD., 24–26 Lever St., Manchester. T., Central 1120; T.A., Buildings, Manchester.

LIND, PETER, & Co., 2 Central Bldgs., Westminster, S.W.1. T., Vic. 3746; T.A., Inneloclin, Phone, London.* (*See p.* 236.)

MONNOYER BRITISH CONSTRUCTION CO., LTD., 6 New Burlington St., W.1. T., Gerrard 6977; T.A., Reyonnom, London.* (*See p.* 237.)

MONOLITHIC & GENERAL CONSTRUCTIONS, LTD., 7 Prince's St., S.W.1. T., Vic. 6487. T.A., Monogenai, Phone, London.*

MOUCHEL, L. G., & PARTNERS, LTD., 36–8 Victoria St., S.W.1. T., Vic. 6506–7; T.A., Hennebique, Sowest, London.

SAXILD & PARTNERS, 2 Central Bldgs., Westminster, S.W.1. T., Vic. 7271; T.A., Saxconcret, Phone, London.* (*See pp.* 238–9.)

STUART'S GRANOLITHIC CO., LTD., 63 Lincoln's Inn Fields, W.C.2. T.. Holborn 5268; T.A., Granolith, Holb., London.*

TOPPING & LEGGAT, 51 Tothill St., S.W.1. T., Vic. 5347; T.A., Smokechim, Vic, London.* (*See p.* 241.)

TRUSSED CONCRETE STEEL CO., LTD., 22 Cranley Gdns., S.W.7. T., Kens. 1049; T.A., Kahncrete, Fulroad, London.

Yorkshire Hennebique Contracting Co., Ltd., Viaduct Works, Kirkstall Rd., Leeds. T., 20687 & 20688; T.A., Ferro, Leeds.*

AGGREGATES AND SAND.

Bedfordshire.—

Brown, B. A., Canal Wharf, Leighton Buzzard. T., 156. (Leighton Buzzard sand.)

Garside, G., Leighton Buzzard. T., 9. (Washed and unwashed sands.)

Ray, F., Cauldwell St., Bedford. T., 54. (Sand and aggregate.)

Cambridgeshire.—

Griffin, C., Wimblington, Cambs. T.A., Griffin, Wimblington, Cambs. (Sand and gravel.)

Derbyshire.—

Boon's Granite Quarries, Ltd., Windmill Hill Quarries, Nuneaton. T., 18; T.A., Boon's Quarries, Nuneaton. (Broken granite and chippings; granite dust.)

Carr, John, & Co., Dronfield. T., 3; T.A., Carr, Dronfield. (Sand; limestone; granite; coke breeze; vitrified clinker.)

Cement Industries, Siddals Rd., Derby. T.A., Cementin, Derby. (Mosaic cubes; terazzo grains; hard flooring grains; abrasives.) (*See pp.* 248–9.)

Hopton-Wood Stone Firms, Ltd., Wirksworth, Derbyshire. T., 9; T.A., Hoptonwood, Wirksworth. (Limestone.)

Long Rake Spar Co., Ltd., Youlgreave, nr. Bakewell. T., Youlgreave 10; T.A., Longrake, Youlgreave. (Derbyshire spar chippings; grit; dust.)

Peters, C. A., Ltd., Stores Rd., Derby. T., 399 T.A., Peters, Derby. (All kinds of fancy aggregates.) (*See p.* 194.)

Stancliffe Estates Co., Ltd., Darley Dale, nr. Matlock. T., 29; T.A., Stancliffe, Two Dales. (Broken gritstone and gritstone sand.) (*See p.* 197.)

Essex.—

Collier Bros., Stanway, nr. Colchester. T., Colchester 2x2; T.A., Collier, Lexden. (Pit sand; washed sand, shingle, and ballast.)

Collier, W. H., & Co., Marks Tey, Colchester. T., 1; T.A., Colliers, Marks-tey. (Washed shingle; sand; washed ballast.)

Livingstone, K., Brantham Hall, Manningtree. T., Holbrook One X; T.A., Keeble, Brantham. (Washed sand; aggregate.)

Gloucestershire.—

Arnold, J., & Sons, Wickwar. T., 6; T.A., Arnoldsons, Wickwar. (Broken limestone chippings; sand.)

Frampton Gravel Co., Frampton-on-Severn. (Gravel.)

Gloucester Concrete Construction Co., Ltd., Hempstead. T., 984; T.A., Ferroship, Gloucester. (Gravel; sand.) (*See p.* 292.)

Hertfordshire.—

Hailey, H., The Croft. Gt. Wymondley, Stevenage. T., Stevenage 74; T.A., Graveley, Stevenage. (Coarse and fine sand; stone; shingle.)

Kent.—

Ashenden, T., & Son, 29 St. Peter's St., Canterbury. T., 150. (Crushed shingle; aggregate.)

Crayford Sand and Gravel Pits, Bowman's Estate, Crayford. T., Bexley Heath 414; T.A., Corke, Sandpits, Crayford. (Ballast; washed sand and shingle; gravel.)

Heath Lane Sand Pits, Dartford. T., 257. ($\frac{1}{8}$ in., $\frac{3}{8}$ in., and $\frac{3}{4}$ in. crushed shingle; ballast; sand; gravel; hoggin.)

Parish, John, & Co., 89 West St., Erith. T., 56; T.A., Parish, Erith. (Sand; ballast.)

Stone Court Chalk Land & Pier Co., Ltd., Stone Court, Stone, nr. Greenhithe. T., Dartford 150; T.A., Quarrier, Greenhithe. (Washed and crushed pit ballast, graded $\frac{3}{4}$ in. to $\frac{1}{4}$ in. and $\frac{3}{8}$ in. to $\frac{5}{32}$ in.; washed pit sand, passing $\frac{5}{32}$ in. sq. mesh.)

Talbot Estates, 37 Pelham Rd., Gravesend. T., Erith 42. (Sand; aggregate.)

Lancashire.—

Chatterton, W., 378 Corn Exchange Bldgs., Hanging Ditch, Manchester. T., City 4816; T.A., Stonechat, Manchester. (Broken stone and granite; quarry and river sand.)

Isherwood Bros., Ltd., 10 Corporation St., Manchester. T., City 1467; T.A., Briquettes, Manchester. (River sand; crushed stone; granite chippings; rock chippings; gritstone chippings.)

Newry Granite Co., Ltd., Manchester Granite Works, Trafford Park, Manchester. T., Trafford Park 4; T.A., Quarries, Manchester. (Broken granite.)

Partington Steel & Iron Co., Ltd., Irlam, nr. Manchester, and Bodfari Limestone Quarry, Bodfari, N. Wales. T., Irlam 11; T.A., Steel, Cadishead. (Blast-furnace slag; limestone.)

Penmaenmawr & Welsh Granite Co., Ltd., 4 Harrington St., Liverpool. T., Bank 4957; T.A., Pavement, Liverpool. (Crushed granite.)

Pwllheli Granite Co., Ltd., 7 Chapel St., Liverpool. T., Central 462; T.A., Gimlet, Liverpool. (Granite macadam and chippings.)

Ship Canal Sand Co., Ltd., Mount Vernon Sand Quarry, Weaste, nr. Manchester. T., Eccles 486. (Sand; broken stone.)

Leicestershire.—

Charnwood Granite Co., Charnwood Quarries, nr. Loughborough. T., Coalville 6; T.A., Charnwood, Bardon Hill. (Broken granite.)

Croft Granite, Brick & Concrete Co., Ltd., Croft, Leicestershire. T., Narborough 13; T.A., Adamant, Croft, Leicestershire. (Granite sand; broken granite; granite chippings; broken rubble and rubble chippings.)

Ellis & Everard, Bardon Hill, nr. Leicester. T., Coalville 6; T.A., Granite, Bardon Hill. (Granite graded to requirements.)

Enderby & Stoney Stanton Granite Co., Ltd., Enderby, nr. Leicester. T., Narborough 6; T.A., Granite, Enderby, Leicester. (Broken granite, all sizes $2\frac{1}{2}$ in. to 1 in.; chippings from $\frac{3}{4}$ in. to $\frac{1}{4}$ in.; granite sand.)

London.—

Boyer, Wm., & Sons, Irongate Wharf, W. (Ballast; sand; shingle.)

Byford, John, & Son, Ltd., Moody Wharf, E.14. T., East 1048; T.A., Byford, Poplar. (Thames ballast; sand; shingle; crushed ballast.)

Child, H. J., 20 Lower Park Rd., S.E.15. T., New Cross 1317. (Washed pit sand; washed crushed ballast, $\frac{3}{8}$ in. and $\frac{3}{4}$ in.; Thames sand and ballast; pit ballast; breeze.) (*See p.* 188.)

Coulson & Co., Coronation Rd., N.W.10. T., Willesden 3372; T.A., Transhaul, Harles, London. (River and pit ballast; pit sand; $\frac{3}{4}$ in. and $\frac{3}{8}$ in. washed and graded shingle.)

Dawson & Co., Ltd., Mendip Wharf, S.W.11. T., Batt. 90. (Sand; ballast; shingle.)

Glarea, Ltd., Bush House, Aldwych, W.C.2. T., City 9472; T.A., Workbench, Phone, London. (Ballast; gravel; shingle; sand.) (*See p.* 191.)

Greenham, H. J., Ltd., Rosebank Wharf, S.W.6. T., Hammersmith 49. (Washed, crushed, and graded ballast.)

Griffiths, Chas., 32 & 34A, Ben Jonson Rd., E.1. T., East 3570. (Pit and Thames sand and ballast; hardcore; broken brick.)

Holliday, J., & Co., Ltd., 17 Temple Chbrs., Temple Ave., E.C.4. T., City 2770. (Sand and ballast.)

Inns & Co., 286 Pentonville Rd., N.1. T., North 3146; T.A., Sandgran, Kincross, London. (Sand; ballast.)

Keep, Frank, Ltd., 9–10 St. Mary at Hill, E.C.3. T., Minories 1843; T.A., Keesh, Bilgate, London. (Graded clinker; breeze.)

Mabey & Johnson, 4 Cullum St., E.C. 3. T., Ave. 8831; T.A., Buildamabe, London. ($\frac{3}{4}$ in. and $\frac{3}{8}$ in. crushed ballast; washed sand.)

Mears, Joseph, Ltd., Crab Tree Wharf, S.W.6. T., Hammersmith 53. (Washed pit sand; $\frac{3}{8}$ in. and $\frac{3}{4}$ in. washed and crushed shingle.)

Merton Sand and Gravel Pits, Ltd., Nelson Fields, Morden Rd., S.W.19. T., Wimbledon 1919. (Sand; aggregate graded $1\frac{1}{4}$ in. to $\frac{1}{4}$ in.)

Neal, G., Blackshaw Rd., S.W.17. T., Wimbledon 1212. (Thames ballast; river sand; pit ballast and sand; crushed ballast; crushed shingle.)

North London Ballast & Sand Co., Ltd., 48 Gray's Inn Rd., W.C.1. T., Holb. 4650; T.A., Dicksoma, London. (Sand; ballast; hoggin.) (*See p.* 193.)

Pritchard, H., & Sons, 40½ New Rd., S.W.8. T., Brixton 425. (Crushed flint, graded and washed.)

Room, E. W., 19 Dulwich Village, S.E. 21. T., Sydenham 744; T.A., Room, Dulwich. (Sand; ballast; gravel.)

Ryarsh Sand Co., Ltd., 1 Queen Anne's Gate, S.W.1. T., Vic. 2824. (Flint; gravel; pea gravel; hoggin; sand.)

Sankey & Co., Ltd., Creek Wharf, King St., Hammersmith. T., Hammersmith 96; T.A., Sankey, Hammersmith. (Granite chippings; washed sand; graded ballast.)

Sankey J. H., & Son, Ltd., Essex Wharf, E.16. T., East 1061; T.A., Sankey, Canning Town. (Thames sand; screened Thames ballast; red pit sand; granite chippings; flints; granite; breeze.)

Scholey, T., & Co., Ltd., Dawson's Wharf, S.E.10. T., Greenwich 61–2. (Thames ballast; crushed ballast; washed sand.)

Supplies & Transport Co., Ltd., 1 Shell Rd., S.E.13. T., Lee Green 1191; T.A., Supplies, Lee Green, 1191. (Thames ballast; washed crushed ballast; washed pit sand; broken brick.)

Thames Sand Dredging Co., Ltd., 19 Eastcheap, E.C.3. T., Central 6022; T.A., Fluviatic, Bilgate, London. (Sand; ballast; shingle.)

Wiggins & Co., Chancellor's Wharf, W.6. T., Hammersnith 2414; T.A., Wiggins, Hammersmith 2414. (Sand; ballast.)

Wilson, G. L., & Co., Ltd., Tottenham, N.17. T., Tottenham 9; T.A., Wilsons, Tottenham. (Pit and Leighton Buzzard sand; ballast.)

Young & Son, Ltd., Rosher's Wharf, E.8. T., Dalston 4080; T.A., Rosher, Kinland, London. (Sand; crushed ballast.)

Middlesex.—

Isleworth Sand & Ballast Co., Ltd., Worton Rd., Isleworth. (Washed, crushed, and graded ballast.)

Lavender, H., & Son, Teddington Park Rd., Teddington. T., Molesey 80. (Washed and pit sand; crushed ballast, all sizes; washed shingle, all sizes.)

HOUNSLOW SAND & GRAVEL CO., LTD., Sutton Lane, Hounslow. T., 274. (Washed sand; crushed and washed shingle.)
THAMES SAND & GRAVEL CO., LTD., Twickenham Park. T., Richmond 2605; T.A., Thames Sand, Gravel, East Twickenham. (Sand; graded ballast; ¾ in. and ⅜ in. shingle; crushed shingle; all washed.)
TWICKENHAM PARK GRAVEL & BUILDING CO., Whitton Dene, Isleworth. T., Hounslow 1479. (Washed ballast, shingle, and sand.)

NORFOLK.—

SNETTISHAM SHINGLE CO., LTD., Snettisham, King's Lynn. T.A., Shingle-beach, Snettisham. (Shingle; sand.) (*See p.* 196.)

NORTHUMBERLAND.—

WARREN, R. & G., LTD., 1 Sandhill, Newcastle-upon-Tyne. T., Central 1347; T.A., Mohaul, Newcastle-upon-Tyne. (Sand; gravel; ballast.)

NOTTINGHAMSHIRE.—

MANSFIELD SAND CO., LTD., Mansfield. T., 36. (Sand.)
TRENT CONCRETE, LTD., Colwick, Nottingham. T., Carlton 62; T.A., Concrete, Netherfield. (Washed Trent sand; aggregate.) (*See p.* 300.)

SHROPSHIRE.—

CEIRIOG GRANITE CO., LTD., 7 & 8 Church St., Shrewsbury. T., 340; T.A., Granomac, Shrewsbury. (Broken granite.)
CLEE HILL GRANITE CO., LTD., Clee Hill, nr. Ludlow. T., Clee Hill 2; T.A., Granite, Clee Hill. (Granite chippings, ¼ in., ½ in., 1 in. and 1¼ in.; mixed chippings, ¼ in., ½ in., and 1 in. to dust; granite dust.)

STAFFORDSHIRE.—

DOSTHILL GRANITE QUARRY CO., LTD., Dosthill, nr. Tamworth. T., 54. (Grey granite chippings in all sizes.)
SHIRE OAK LAND, GRAVEL, AND CONCRETE WORKS, Stonnall, Walsall. T., 31; T.A., Concrete, Walsall Wood. (Sand; 2 in. to ¼ in. aggregate.)

SUFFOLK.—

BEAR, W. F., Babergh Heath, Acton, Sudbury. T.A., Bear, Acton, Suffolk. (Sand; ballast; black flints; gravel.)

SURREY.—

HALL & CO., LTD., Victoria Wharf, Croydon. T., 1103; T.A., Cement, Croydon. (Pit sand; graded ballast.)
PATTERSON, T., & SON, LTD., Firgrove Hill, Farnham. T., Farnham 39; T.A., Flints, Farnham. (Sand; gravel; crushed ballast.)

YORKSHIRE.—

BROOKES, LTD., Halifax. T., Hipperholme 101; T.A., Brookes, Halifax. (Granite chippings.)
HENSALL CONCRETES, LTD., 28 Eldon St., Barnsley. (Sand; gravel.)
MOXON, GEO., & SONS, LTD., Hillhouse, Huddersfield. T., 166–7; T.A., Coke, Huddersfield. (Coke breeze.)
SCOTTER, W., LTD., Victoria Chbrs., Bowlalley Lane, Hull. T., 3977–9; T.A., Mining, Hull. (Screened and unscreened coke breeze; ½ in. coke dust.)
WALKER, J. H., & Co., Layerthorpe Bridge, York. T., 251. (Sand, river and pit; gravel, washed and screened; stone, crushed and screened.) (*See p.* 198.)
WHITAKER, B., & SONS (1923), LTD., 4 Albion St., Leeds. T., 27335–6; T.A., Quarries, Leeds. (Sand and gravel, washed and graded; quarry sand; broken stone.)

Scotland.—

Bain & Brown, Ltd., 236 Leith Walk, Leith. T. 346. (Sand; crushed stone; gravel.) (*See p.* 226.)

Davidson, J., 51 Quality St., Dysart. (Sand; gravel.)

Dundee Sand & Lighterage Co., Ltd., 21 Dock St., Dundee (T., 2052; T.A., Emplomutua); and Shore, Perth (T., 242). (River and pit sand; graded gravel ballast.) (*See p.* 190.)

Hall, G., Back Hilton Rd., Aberdeen. T., 1348; T.A., Quartz, Aberdeen. (Sand; gravel; crushed granite.)

Hastie, D., & Sons, Stonefield, Blantyre. T., 50. (Sand.)

Henderson, J. & W., Ltd., 29 Queen St., Edinburgh. T., 2697; T.A., Quarries, Edinburgh. (Sand; gravel; whin chips and metal; granite chips.)

Hillhouse Quarry Co., Hillhouse and Parkthorn Quarries, Troon. T., 36; T.A., Hillhouse Quarry, Troon. (Broken whinstone.) (*See p.* 192.)

McCreath, Taylor & Co., 170 Hope St., Glasgow. T., Douglas 3845; T.A., Rapidity, Glasgow. (Broken granite; broken whinstone; broken slag; sand.)

Paton, John D., Ltd., 5 Green St., Ayr. T., 71; T.A., Cement, Ayr. (Sand; aggregates.)

Sandhills Co., 101 Leith Walk, Leith. T., 272; T.A., Sandhills, Leith. (Sand; gravel.) (*See p.* 195.)

Warnock, Bros., 30 Abercorn St., Paisley. T., 2223; T.A., Argo, Paisley. (Sand; gravel.)

Watson, W., & Sons, Foxley Quarries, Tollcross, Glasgow. T., Shettleston 2. (Sand; gravel.)

Wilson, Alex. J., Balgownie Granite Works, Merkland Rd. East, Aberdeen. T., 717; T.A., Slabs, Aberdeen. (Granite chippings.)

Wales.—

Craig-Lelo Quarry Co., Ltd., Gwyddelwern, nr. Corwen, N. Wales. T., Corwen 23; T.A., Lilo, Gwyddelwern. (Granite chippings; granite sand.) (*See p.* 290.)

Dee-Clwyd Granite Quarries Co., Ltd., Gwyddelwern, nr. Corwen, N. Wales. T., Corwen 27; T.A., Dee-Clwyd, Gwyddelwern. (Blue Welsh granite.) (*See p.* 189.)

Griffiths, J. & R., Ltd., West Canal Wharf, Cardiff. T., 6335; T.A., Building, Cardiff. (Sand; gravel; granite; pennant; limestone.)

Sessions & Sons, Ltd., Penarth Rd., Cardiff. T., 2560; T.A., Sessions, Cardiff. (Sand; gravel; broken stone.)

Slate Industries, Ltd., Coetmor Yard, Bethesda, N. Wales. T., 4. (Aggregates; sands; powders.) (*See p.* 308.)

Ireland.—

Giants' Causeway Columnar Basalt Co., Ltd., Portrush, Co. Antrim. T., 29; T.A., Columnar, Portrush. (Basalt screenings.)

Gregg, George, & Sons, 142 Royal Ave., Belfast. T., 3024; T.A., Macadam, Belfast. (Sand; blue stone; screenings.)

Inland Navigation Co., Ltd., 80 High St., Belfast. T., 377; T.A., Canal, Belfast. (Sand.)

Macnaughton, N., & Sons, Ltd., 101 Corporation St., Belfast. T., 4641; T.A., Cement, Belfast. (Broken basalt and screenings; granite chippings and crushed granite; basalt sand; sea and freshwater sands.)

Sheils, J., Logan Bank Rd., Belfast. T., 1239. (Sea sand and gravel; Lough Neagh sand.)

ARCHITECTURAL CAST STONE AND PAVING SLABS.

(See also "Products," p. 170.)

Acme Flooring & Paving Co. (1904), Ltd., Gainsborough Rd., E.9. T. East 5060; T.A., Dowelled, London.

Alexandra Paving Stone Co., Ltd., Vernon House, Sicilian Ave., W.C.1. T., Museum 4107; T.A., Calandgic, London.

Bain & Brown, Ltd., 236 Leith Walk, Leith. T., 346. (*See p.* 226.)

Blokcrete Co., Broadlands Rd., Hampton Park, Southampton. T., Bassett 67'; T.A., Blokcrete, Hampton Park, Southampton.

Bonsall, S. H., Railway Works, Cheadle Heath, Stockport. T., 2298; T.A., Bonsall, Stockport, 2298.

Bradford, F., & Co., Coopersale Rd., E.9. T., Dalston 345.

Bradshaw, E., & Son, 322 Fawcett Rd., Portsmouth. T., 4506.

Bristol Concrete Co., Ltd., Blackwell, Bristol. T., Flax Bourton 47; T.A., Blackwell, Bristol. (*See p.* 280.)

Brookes, Ltd., 65 Victoria St., S.W.1. T., Vic. 4622; T.A., Pitchstone, Phone, London.

Cambridge Artificial Stone Co., Ltd., Mill Rd., Cambridge. T., 1275; T.A., Hartley, 1275, Cambridge.

Cement Industries, Siddals Rd., Derby. T.A., Cementin, Derby. (Special intricate and artistic work only.) (*See pp.* 282–5.)

Christie Patent Stone Co., Ltd., Christie Rd., Stretford, nr. Manchester.

Cliffe Hill Granite Co., Ltd., Markfield, nr. Leicester. T., Coalville 32

Concrete Manufacturers (No. 1 London), Ltd., Brimsdown, Middlesex. T., Enfield 682; T.A., Darrobsco, Ave, London. (*See pp.* 288–9.)

Concrete Units, Strood Dock, Rochester. T., Chatham 284; T.A., Concrete Units, Chatham, 284.

Craig-Lelo Quarry Co., Ltd., Gwyddelwern, nr. Corwen, N. Wales. (*See p.* 290.)

Empire Stone Co., Ltd., 231 Strand, W.C.2. T., Gerrard 8752; T.A., Empirstone, London.

Evans Bros., Riddings, Alfreton. T., Riddings 3; T.A., Evans, Riddings. (*See p.* 291.)

Excelsior Patent Stone Co., Ltd., Finedon Sidings, Northants. T., Finedon 10; T.A., Excelsior, Finedon.

Fleetwood Granite Co., Ltd., Copse Rd., Fleetwood. T., 525; T.A., Granite Co., Fleetwood.

Fram Reinforced Concrete Co., Ltd., 37 Princess St., Manchester. T., City 4128; T.A., Mimosa, Manchester.

Gloucester Concrete Construction Co., Ltd., Bristol Rd., Hempstead, Gloucester. T., Gloucester 984; T.A., Ferroship, Gloucester. (*See p.* 292.)

Hebdon Concrete Co., 56 Pittencrieff St., Dunfermline.

Henderson, J. & W., Ltd., 29 Queen St., Edinburgh. T., 2697; T.A., Quarries, Edinburgh.

Hull Concrete Stone Co., Ltd., Lorraine St., Hull. T., Corpn. 1289.

Leckhampton Quarries Co., Ltd., Sandy Lane, Charlton Kings, nr. Cheltenham. T., 1044; T.A., Leckhampton Quarries, Cheltenham.

Lill, Henry, Drummond Rd., Skegness. T., 115; T.A., Lill, Skegness, 115. (*See p.* 293.)

Lindum Stone Co., 85 Canwick Rd., Lincoln. (*See pp.* 294–5.)

Liverpool Artificial Stone Co., Ltd., Picton Rd., Wavertree, Liverpool. T., Wavertree 1030; T.A., Breslabs, Liverpool. (*See p.* 297.)

McDowell, A., & Co., 33 Northbrook St., Belfast. T., 828.

Macleod, Malcolm, & Co., Ltd., Glen Rd., E.17. T., Walthamstow 522; T.A., Macleod, 522, Walthamstow.

Manufactured Concrete Works, Ltd., 39 Victoria St., S.W.1. T., Vic. 5159; T.A., Ramified, Sowest, London.

Menzies, T. & G., 5 Bennochy Rd., Kirkcaldy. T., 158.

Nonslip Stone Co., Halifax. T.A., Nonslip, Halifax.

Patent Impervious Stone & Construction Co., Ltd., Rutland Works, Lea Bridge Rd., E.10. T., Walthamstow 432; T.A., Construction, London.

Patent Victoria Stone Co., Ltd., 155 Bishopsgate, E.C.2. T., London Wall 2866.

Pearson Bros. & Campbell, Ltd., 24 Chapel St., Liverpool. T., Bank 3584; T.A., Keystone, Liverpool.

Pyx Granite Co., Ltd., Redland Rd., Malvern Link. T., Malvern 141; T.A., Concrete, Malvern.

St. Fort Artificial Stone Co., St. Fort Station, Fifeshire.

Sharp, Jones & Co., Ltd., Bourne Valley Works, Parkstone, Dorset. T., Bournemouth 406; T.A., Henry, Bournemouth.

Smith, George, & Sons, Dunnikier Rd., Kirkcaldy. T., 178.

Street & Co., Townhill, Dunfermline. T., 283; T.A., Street, Townhill.

Stuart's Granolithic Co., Ltd., 63 Lincoln's Inn Fields, W.C.2. T., Holborn 5268; T.A., Granolith, Holb, London.

Thompson, J. & R., Ltd., 128 Roden St., Belfast. T., 804.

Trent Concrete, Ltd., Colwick, Nottingham. T., Carlton 62; T.A., Concrete, Netherfield. (*See p.* 300.)

Wallis, G. E., & Sons, Ltd., Broadmead Works, Maidstone. T., 31; T.A., Wallis, Builders, Maidstone.

Wharf Lane Concrete Co., Ltd., Station Rd., Ilminster. T., 36. (*See p.* 301.)

Wilkinson's, Bordon, Hants. T.A., Wilkinson, Bordon.

Wilson, J., Concrete Factory, Lossiemouth. T.A., Wilson, Lossiemouth.

ASBESTOS-CEMENT PRODUCTS.

(*The nature of the products supplied by each firm is given in brackets.*)

Asbestos Roofings Co., 36–8, Kingsway, W.C.2. T., Holborn 1478; T.A., Asbestiled, Westcent, London. (Asbestos-cement slates and sheets.)

Bell's Poilite and Everite Co., Ltd., Southwark St., London, E.C.1. T., Hop. 4040; T.A., Belfry, London. (Sheets, flat and corrugated; tiles; pantiles.)

British Fibrocement Works, Ltd., Erith. T., Erith 89; T.A., Fibrocement, Erith. (Asbestos-cement corrugated sheets, tiles, slates; panelled and flat sheets.)

British Roofing Co., 150 Southampton Row, W.C.1 T., Museum 5192; T.A., Rotagilla, Westcent, London.

British Uralite and Cellactite Works, Lincoln House, High Holborn, W.C 1. T., Holborn 1760; T.A., Uranicos, Holb, London.

Eternit Pietra Artificiale (London), Ltd., Norfolk House, Laurence Pountney Hill, E.C.4. T., City 8886. T.A., Italitibes, Cannon, London. ("Italit" corrugated roofing sheets.) (*See p.* 199.)

Hobdell, Way & Co., Ltd., 45 Church St., E.1. T., Royal 3810; T.A., Hobnails, Ald, London. (Sheets, curved and corrugated; slates.)

Martinit Slate and Sheet Co., Ltd., Africa House, Kingsway, W.C.2. T., Holborn 2300; T.A., Cromsteed, Telew, London. (Asbestos-cement tiles; flat and corrugated sheets.)

Price, F. G.; & Co., Limpet Works, Carmyle, Glasgow. T., Shettleston 125; T.A., Limpet, Glasgow. (Slates; sheets; roofings.)

Smeed, Dean & Co., Ltd., Sittingbourne. T., 91; T.A., Smeedean, Sittingbourne. ("Entosite" tiles.)

Speaker, G. R., & Co., Eternit House, Stevenage Rd., S.W. T., Putney 2510; T.A., Eternitite, London.

Stamford Building Co., Ltd., Railway St., Dukinfield. T., Ashton 295. (Asbestos-cement sheets; buildings to order only.)

Turner Bros. Asbestos Co., Ltd., Rochdale. T., 941; T.A., Turners, Rochdale.

CEMENT-MAKING MACHINERY.

Allen, Edgar, & Co., Ltd., Imperial Steel Works, Sheffield. T., Attercliffe 360; T.A., Allen, Sheffield. (Complete cement-making machinery; rotary kilns; ball mills; tube mills; combination mills; jaw-crushers; air-separators; crushing and grinding plant.)

Boyd, Edward, & Sons, Hope Iron Works, Holderness Rd., Hull. T., Central 6811; T.A., Hopeful, Hull. (Slurry pumps; mixers; conveyors; clinker weighers; iron castings; grinding mediums.)

Head, Wrightson & Co., Ltd., Thornaby-on-Tees. T., 587; T.A., Teesdale, Stockton. (Cement plant.)

Helipebs, Ltd., Premier Works, Gloucester. T., 971; T.A., Holpebes, Gloucester. (Metallic grinding bodies; steel balls; steel "cylpebs"; "ballpebs"—for the wet process.)

Johnson, Wm., & Sons (Leeds), Ltd., Castleton Foundry, Armley, Leeds. T., 26853; T.A., Ronksley, Armley. (Complete plant.)

Newell, Ernest, & Co., Ltd., Misterton, Doncaster. T., Misterton 11; T.A., Newells, Misterton, Notts.

Potter, F. W., Phipp St., E.C. T., Bishopsgate 2177; T.A., Wirework, Finsquare, London. (Perforated metals; gears; fans; sieves and screens; wire cloth.) (*See p.* 200.)

Ransome, A., & Co., Ltd., Stanley Works, Newark-on-Trent. T., 119; T.A., Ransome, Newark. (Machinery for making cement barrels.)

Ruston & Hornsby, Ltd., Sheaf Iron Works, Lincoln. T., 580; T.A., Ruston, Lincoln. (Excavators.)

Whessoe Foundry & Engineering Co., Ltd., Darlington. T., 2734; T.A., Whessoe, Darlington. (Steel tanks; cast-iron tanks; purifiers; condensers; washer scrubbers; weighbridges and machines.)

Wire Tie Co., Siddals Rd., Derby. T.A., Wiringtie, Derby. (Wire bag ties.) (*See p.* 317.)

CEMENT MANUFACTURERS.

Aberthaw & Bristol Channel Portland Cement Co., Ltd., and Aberthaw & Rhoose Portland Cement and Lime Co., Ltd., Merthyr House, Cardiff. T., 5220; T.A., Beynon, Cardiff. ("Druid" and "Mitre" Brands.)

Adamite Co., Ltd., Regent House, Regent St., S.W.1. T., Mayfair 224; T.A., Excellence, London. ("Atlas White" Brands.)

Associated Portland Cement Manufacturers, Ltd., Portland House, Lloyd's Ave., E.C.3. T., Ave. 5690; T.A., Assoporcem, Fen, London. ("J. B. White & Bros.," "Hilton Anderson," "Burham," "Nine Elms," "Ferrocrete," etc., Brands. (*See p.* 201.)

Barham Brothers, Proprietors of West of England Portland Cement & Lime Co., Ltd., East Quay, Bridgwater. T., 180; T.A., Barham, Bridgwater. ("Rock" Brand.)

Barnstone Cement Co., Ltd., Barnstone, Notts. T., Bingham 23; T.A., Cement, Barnstone. ("Barnstone" Brand.)

British Portland Cement Manufacturers, Ltd., 4 Lloyd's Ave., E.C.3. T., Ave. 6404; T.A., Britporcem, Fen, London. ("Johnson's," "Peters'," "Lee's," "Sun," "Saxon," etc., Brands.) (*See p.* 202.)

British Standard Cement Co., 110 Fenchurch St., E.C.3. T., Avenue 192. ("Capstan" Brand.) (*See p.* 203.)

Broad & Co., Ltd., 4 South Wharf, W.2. T., Paddington 8; T.A., Broadanco, London. ("Blackfriar" Brand.)

Burley, C., Ltd., Sittingbourne. T., 9; T.A., Burley, Sittingbourne. ("Dolphin" Brand.)

Byford, John, & Son, Ltd., Moody Wharf, E.14. T., East 1048; T.A., Byford, Poplar. ("Griffin" Brand.)

Cam Blue Lias Lime & Cement Co., Ltd., Meldreth, Royston, Cambs. T.A., Cam, Meldreth. ("Cam" and "Submarine" Brands.)

Casebourne & Co., Ltd., Pioneer Cement Works, Haverton, Hill-on-Tees. T., 715–716; T.A., Portland, Middlesbrough. ("Pioneer" Brand.)

Cement Industries, Siddals Rd., Derby. T.A., Cementin, Derby. (Special fancy casting cements; coloured flooring cements; green tennis court cements and mixtures; imitation granite cements and mixtures; polishable cements for marble making, etc.) (*See pp.* 204–7.)

Cement Marketing Co., Ltd. (Selling Organisation for Associated Portland Cement Manufacturers, Ltd.; British Portland Cement Manufacturers, Ltd.; Martin Earle & Co., Ltd.; Wouldham Cement Co., Ltd.), 8 Lloyd's Ave., E.C.3. T., Ave. 5690; T.A., Portland, Fen, London. (*See pp.* 208–9.)

Central Portland Cement Co., Ltd., Tunnel Works, Kirton Lindsey Lincs. T., 16; T.A., Lias, Kirton Lindsey. ("Cæsar" Brand.)

Coltness Iron Co., Ltd., Newmains, Lanarkshire. T., Wishaw 212; T.A., Coltness, Newmains. ("Coltness" Brand.)

Earle, G. & T., Ltd., Wilmington, Hull. T., Cent. 4322 and Corpn. 807; T.A., Cement, Hull. (Lead-sealed "Pelican" brand of Earle's cement; Robson's brand of Portland cement.) (*See p.* 210.)

Glasgow Iron & Steel Co., Ltd., Wishaw, Lanarkshire; and 28 Royal Exchange Sq., Glasgow. T., Central 6720; T.A., Giscol, Glasgow. ("Glasgow" and "Giscol" Brands.)

Greaves, Bull & Lakin, Ltd., Harbury, nr. Leamington. T., Southam 7; T.A., Greaves, Harbury. ("Greaves" Brand.) (*See p.* 211.)

Humber Portland Cement Co., Ltd., Melton Brough, E. Yorks. T., Ferriby, Hull, 103; T.A., Supreme, Hull. ("Humber" Brand.)

Isis Portland Cement Co., Ltd., Horrocksford Sidings, Clitheroe, Lancs. T., 12; T.A., Isis, Clitheroe. ("Isis" Brand.)

Kaye & Co., Ltd., Southam Works, nr. Rugby. T., Southam 2; T.A., Kaye, Southam. (Kaye's Brand.)

Lafarge Aluminous Cement Co., Ltd., Regent House, Kingsway, W.C. T.A., Cimenfondu, Westcent, London; T., Gerrard 8137 (Ciment Fondu.)

Lewes Portland Cement & Lime Co., Ltd., South St., Lewes. T., 100; T.A., Calcine, Lewes. ("G. & B" Brand.)

MARTIN, EARLE & Co., LTD., 8 Lloyds Avenue, E.C.3. T., Av. 5420; T.A., Vavasour, London. ("Rhinoceros" Brand.) (*See p.* 212.)

MASON'S PORTLAND CEMENT Co., LTD., Claydon, nr. Ipswich. T., Ipswich 268; T.A., Mason, Claydon, Ipswich. (Mason's "English" Rotary.)

NELSON, CHARLES, & Co., LTD., Stockton, nr. Rugby. T., Southam 5; T.A., Nelson, Stockton, Warwickshire. ("Cock" Brand.) (*See p.* 213.)

OXFORD PORTLAND CEMENT Co., LTD., Kirtlington, Oxon. T.A., Cement, Kirtlington. ("Oxford" Brand.)

RHEE VALLEY PORTLAND CEMENT WORKS, Chancellor's Wharf, London, W.6. T., Hammersmith 2418; T.A., Rheevalcem, Phone, London. ("Rhee Valley" Brand.)

RUGBY PORTLAND CEMENT Co., Rugby. T., 29; T.A., Cement, Rugby. ("Crown" Brand.)

SHIP CANAL PORTLAND CEMENT MANUFACTURERS, LTD., Ellesmere Port, Cheshire. T., 53; T.A., Cement, Ellesmere Port. ("England" Brand.) (*See pp.* 214–5.)

SMEED, DEAN & Co., LTD., Sittingbourne. T., 91; T.A., Smeedean, Sittingbourne. ("S.D." Brand.)

SOUTH WALES PORTLAND CEMENT AND LIME Co., LTD., Penarth, Glamorgan. T., 300; T.A., Cement, Penarth. ("Dragon," "Colossus," and "Severn" Brands.) (*See p.* 216.)

STEPHENSON, ROBERT, & SON, LTD., Burwell, Cambridgeshire. T., Fordham 4; T.A., Portland, Burwell. ("Stephenson's" Brand.)

SUPER-CEMENT, LTD., 10 Upper Woburn Place, W.C. T., Museum 2490; T.A., Cemsoopa, Kincross, London. ("Submarine" Brand.) (*See p.* 217.)

THAMES PORTLAND CEMENT Co., LTD., 74 Coleman St., E.C.2. T., London Wall 9009; T.A., Temsoment, Phone, London. ("Fortclif" Brand.)

TUNNEL PORTLAND CEMENT Co., LTD., West Thurrock, Essex; and 4, Lloyd's Ave., E.C. T., Tilbury 123; T.A., Terrorless, West Thurrock. ("Tunnel" and "Tilbury" Brands.)

WARREN CEMENT WORKS, LTD., Hartlepool. T., 6058; T.A., Cement Hartlepool. ("Warren" Brand.)

WOULDHAM CEMENT Co., LTD., 8 Lloyds Avenue, E.C.3. T., Avenue 5420; T.A., Enriching, Fen, London. ("Maltese Cross," "Union Jack," "Keystone," and "Delta" Brands.) (*See p.* 218.)

CEMENT TESTERS.

BIRMINGHAM TEST HOUSE, 38A Paradise St., Birmingham. T., Midland 91.

FAIJA, HENRY, & Co. (D. B. BUTLER), 6 Earl St., S.W.1. T., Vic. 5054; T.A., Faija, London.

Kirkaldy, David, & Son, 99 Southwark St., S.E.1. T., Hop 2439.

National Physical Laboratory, Teddington. T., 3360; T.A., Physics Teddington.

Riley, Harbord & Law, 16 Victoria St., S.W.1. T., Vic. 2661; T.A., Harbordlab, Phone, London.

Stanger, R. H. H., 24–28 Tothill St., S.W.1. T., Vic. 4693.

Woodcock & Mellersh (late Bertram Blount), 76 Petty France, S.W.1. T., Vic. 8180.

CEMENT TESTING CHEMICALS AND APPARATUS.

Baird, Andrew H., 33–39 Lothian St., Edinburgh. T., Central 916; T.A., Radium, Edinburgh. (Chemicals; laboratory equipment.)

Buckton, Joshua, & Co., Ltd., Well House Foundry, Leeds. T., 20585; T.A., Bucktons, Leeds. (Testing machines.)

Denison, Saml., & Son, Ltd., Moorfields, Leeds. T., 1883; T.A., Denwatest, Sowest, London. (Testing machines.)

Gallenkamp, A., & Co., Ltd., 19–21 Sun St., E.C.2. T., London Wall 1404–5; T.A., Gallenkamp, Finsquare, London. (Laboratory apparatus; electrically-heated apparatus and furnaces.)

Greening, N., & Sons, Ltd., 16 Finsbury St., E.C.2. T., Clerkenwell 1082; T.A., Setscrew, Finsquare, London. (Wire sieves and screens.)

Griffin, John J., & Sons, Ltd., Kemble St., W.C.2. T., Gerrard 2621; T.A., Gramme, Westcent, London. (Cement testing apparatus and appliances; scientific apparatus; balances; chemicals.)

Macklow-Smith, A., Queen Anne's Chbrs., S.W.1. T., Vic. 5369. (Testing machines and appliances; extensometers and measuring instruments; cement machines and moulds.)

Potter, F. W., & Co., Phipp St., E.C.2. T., Bishopsgate 2177; T.A., Wirework, Finsquare, London. (Wire gauze; sieves; screens; perforated metals.) (*See p.* 200.)

Scientific Supplies Co., Ltd., 52 Hatton Garden, E.C.1. T., Holborn 6264; T.A., Sciensupl, Smith, London. (Thermometers; research glassware; laboratory equipment.)

Woolley, James, Sons & Co., Ltd., 76 Deansgate, Manchester. T., City 7942; T.A., Pharmacy, Manchester. (Apparatus and chemicals; scientific instruments.) (*See p.* 219.)

COLOURED CEMENTS.

CEMENT INDUSTRIES, Siddals Rd., Derby. T.A., Cementin, Derby. (*See pp.* 220.)

C. A. PETERS, LTD., Stores Rd., Derby. T., 399; T.A., Peters, Derby. (*See p.* 221.)

COLOURING MATERIALS.

BAILEY, WILLIAM, & SON, Horseley Fields Works, Wolverhampton. T., 463; T.A., Industria, Wolverhampton. (Red, green, brown, black, grey.)

BUILDING PRODUCTS, LTD., 44–46 King's Rd., Sloane Sq., S.W.3. T., Vic. 2590; T.A., Bylprodia, Sloane, London. (Grey, red, green. Other colours to order.) (*See p.* 304.)

CEMENT INDUSTRIES, Siddals Rd., Derby. T.A., Cementin, Derby. (Dry colours; all shades.) (*See p.* 222.)

COLOURS AND CHEMICALS, LTD., King's House, King St., E.C.2. T., Bank 8258; T.A., Thickness, Cent, London. (Brown, blue, green, black, light red, deep red, purple, yellow.)

DIXONS WHITE, LTD., Old Ford Rd., Bow, E. T., East 1246; T.A., Dryolene, Bochurch, London.

FREEMAN, JOSEPH, SONS & CO., LTD., Wandle Colour Works, S.W.18. T., Battersea 596; T.A., Lippi, Phone, London. (Red, blue, brown, green, marigold, black, yellow.)

GOLDEN VALLEY OCHRE & OXIDE CO., LTD., Wick, nr. Bristol. T., Kingswood 162; T.A., Ochre, Wick, Glos. (All colours.)

HULSE, F., & CO., LTD., Woodlesford, nr. Leeds. T., Rothwell 71; T.A., Hulse, Woodlesford. (Black, grey, brown.)

JENSSON & NICHOLSON, LTD., Goswell Works, Stratford, E. T., East 760; T.A., Varnish, London.

PETERS, C. A., LTD., Stores Road Works, Derby. (Coloured cements in all shades.) (*See p.* 223.)

R.I.W. PROTECTIVE PRODUCTS CO., LTD. (*See* Toch Bros.)

SILICATE PAINT CO., LTD., Charlton, S.E. T., Greenwich 36; T.A., Orr, London.

TOCH BROS., 74 Vicarage Lane, E.15. T., Maryland 1589; T.A., Cemenflor, Strat, London. (14 standard colours, all shades.) (*See p.* 224.)

VERDURA HARD COURT CO., Derwent Chambers, Derby. (Coloured cements for hard tennis courts.) (*See p.* 250.)

WILDE, HENRY, & CO., 66 Victoria St., S.W.1. T., Vic. 8960; T.A., Utilissand, London. (All colours.)

CONTRACTORS FOR CONCRETE CONSTRUCTION.

Berkshire.—

Collier & Catley, Ltd., St. Mary's Butts, Reading. T., 93.
Hughes, E. C., Albion Works, Wokingham. T., 7.
Wait, Edwin, North End, Newbury. T., Highclere 1Y4; T.A., Wait, Woolton Hill. (*See p.* 242.)

Buckinghamshire.—

Jackaman, A., & Son, Ltd., 22 Mackenzie St., Slough. T., 31; T.A., Jackaman, Slough. (*See p.* 234.)

Cambridgeshire.—

Saint, William, Ltd., St. Barnabas Rd., Cambridge. T., 157; T.A., Contracts, Cambridge.

Cornwall.—

Sherwood Hunter, Ltd., Newlyn, Penzance. T., Penzance, 234; T.A., Chasseur, Penzance.

Cumberland.—

Laing, John, & Son, Ltd., Dalston Rd., Carlisle. T., 182; T.A., Laings, 182, Carlisle.

Derbyshire.—

Evans Bros., Riddings, Alfreton. T., Riddings 3; T.A., Evans Bros., Riddings. (*See p.* 291.)
Ford, J. K., & Weston, Ltd., Osmaston Rd., Derby. T., 359; T.A., 359, Derby.
Gee, Samuel, & Sons, Ltd., Uttoxeter Old Rd., Derby. T., 120; T.A., Estimator, Derby.
Lehane, R., & Co., Ltd., Darley Dale. T., 5; T.A., Lehane, Darley Dale.
Perks, F., & Son, Ltd., Long Eaton. T., 43; T.A., Perks, Long Eaton, 43.
Tomlinson, G. F., City Rd., Derby. T., 350; T.A., Concrete, Derby.
Walker & Slater, Ltd., Uttoxeter Old Rd., Derby. T., 120; T.A., Estimator, Derby.

Devonshire.—

Shellabear, G., & Son, Ltd., Alton House, Mutley Plain, Plymouth. T. 856; T.A., Shellabears, Contractors, Plymouth.

Gloucestershire.—

Cowlin, William, & Son, Stratton St., Bristol. T., 3132; T.A., Construct, Bristol.
Drew, W. F., Ltd., Chalford.
Ford, Philip, & Son, Slad Rd., Stroud. T., 127; T.A., Ford & Son, Stroud.
Gardner & Sons, 6 King St., Stroud. T., 196.
Halls, W. J. B., Ltd., Barton Gates, Gloucester. T., 893.
Hobrough & Co., Ltd., 26 Clarence St., Gloucester. T., 203; T.A., Hobrough, Gloucester.
Holborow & Sons, Market Pl., Tetbury. T., Tetbury 20; T.A., Contracts, Tetbury.

NICHOLLS, WILLIAM T., LTD., St. Paul's Rd., Gloucester. T., 215; T.A., Nicholls, Builders, Gloucester.
WILKINS, R., & SONS, LTD., 20 Bishop St., St. Paul's, Bristol. T., 473; T.A., Wilkins, Bishop St., Bristol.

HAMPSHIRE.—

BEVIS, FRANK, LTD., Portsmouth. T., 3286; T.A., Frank Bevis, Portsmouth. (*See p.* 227.)
GROUNDS & NEWTON (C. D. NEWTON), Hampstead House, Yelverton Rd., Bournemouth. T., 992; T.A., Newton, Contractor, Bournemouth.
TOOLE, PLAYFAIR, LTD., Northam Bridge Works, Southampton. T., 3400; T.A., Freestone, Southampton.

HERTFORDSHIRE.—

GINN, RICHARD, & SON, St. Andrew's Works, Hertford. T., 22; T.A., Ginn, Hertford.
MISKIN, C., & SONS, LTD., Romeland, St. Albans. T., Chancery 7865; T.A., Miskin, St. Albans.

KENT.—

BATES, T., & SONS, LTD., 6 Nevill Terrace, Tunbridge Wells. T., 350; T.A., Bates, Tunbridge Wells, 350.
WALLIS, G. E., & SONS, LTD., Broadmead Works, Hart St., Maidstone.

LANCASHIRE.—

BOLTON & HEYES, LTD., Rose Hill Yd., Manchester Rd., Bolton. T., 338.
BRADSHAW, JOSEPH H., LTD., 4 St. Mary's Parsonage, Manchester. T., Central 4359; T.A., Bradphalte, Manchester.
BYROM, JAMES, LTD., Bury. T., 784; T.A., Byrom, Contractors, Bury.
COMBINED CONCRETE CONSTRUCTION CO., LTD., 23 Strutt St., Manchester. T., City 4374; T.A., Ferteros, Manchester.
DICKINSON, JOHN, & CO. (BOLTON), LTD., Fairclough St., Bolton. T., 1892; T.A., Dickinsons, 1892, Bolton.
FRAM REINFORCED CONCRETE CO., LTD., 37 Princess St., Manchester. T., City 4128; T.A., Mimosa, Manchester.
FREEMAN, F. G. V., Albert St., Hollinwood. T., Oldham 2019; T.A., Freeman, Contractor, Hollinwood.
GORNALL, WM., & SONS, LTD., Ellesmere St., Bolton. T., 1658; T.A., 4399, City, Manchester.
HALL, WILLIAM, & SON, LTD., 60 & 62 Christian St., Liverpool. T., North 1447.
HAYES, FRANK, 31 North John St., Liverpool. T., Bank 9057; T.A., Irrigate, Liverpool.
HOWARTH, R. & T., Crossfield Works, Norwich St., Rochdale. T., 1227; T.A., Howarth's, 1227, Rochdale.
HUGHES & STIRLING, Victoria Works, Brasenose Rd., Bootle. T., 821; T.A., Hughes-Stirling, Bootle.
MOSS, WILLIAM, & SONS, LTD., Roscoe St., Liverpool. T., Royal 1081–2; T.A., Reinforced, Liverpool.
MULLEN & DURKIN, LTD., Trafalgar St., Burnley. T., 281; T.A., Build Burnley.
NUTTALL, EDMUND, SONS & CO., LTD., Trafford Park, Manchester. T., Trafford Park 310; T.A., Tunnelling, Manchester.
SIMON-CARVES, LTD., 20 Mount St., Manchester. T., City 8200; T.A., Simcar, Manchester.

SMETHURST, S. & J., LTD., Rochdale Rd., Oldham. T., 194; T.A., Buildhurst, Oldham.
SNAPE, W., & SONS, Boardman St., Eccles. T., 542; T.A., Snape, 542, Eccles.
THOMAS & JONES, LTD., Moor St., Rusholme, Manchester. T., Rusholme 164.
TOWNSON, WILLIAM, & SONS, LTD., Park Hill, Bolton. T., 1840; T.A., Townsons, Builders, Bolton.
WILSON, THOMAS, 78 Broad St., Pendleton, Manchester. T., Pendleton 783.
WORTHINGTON, W. H., LTD., 61 Rusholme Rd., Manchester. T., Central 2957 & 2958; T.A., Flagging, Manchester. (*See p.* 244.)

LEICESTERSHIRE.—

CHAPMAN, J., & SONS, LTD., Knighton Junction, Leicester. T., 2234; T.A., Chapmans, 2234, Leicester.
CLARKE, ERNEST, King's Rd., Melton Mowbray. T., 2; T.A., Clarke, Contractor, Melton Mowbray.

LINCOLNSHIRE.—

WRIGHT, WM., & SON (LINCOLN), LTD., Park St., Lincoln. T., 205; T.A., Wrightson, Lincoln.

LONDON.—

ANGLO-DANISH CONCRETE CONSTRUCTION CO., LTD., 7 & 8 Norfolk St., W.C.2. T., Central 6138; T.A., Anglodany, Estrand, London. (*See p.* 225.)
ARMSTRONG, SIR W. G., WHITWORTH & CO., LTD., 8 St. George St., S.W.1. T., Vic. 4010.
ASHBY & HORNER, LTD., 8 Aldgate, E.1. T., Avenue 5881.
BALDRY, YERBURGH & HUTCHINSON, LTD., 21 Queen Anne's Gate, S.W.1. T., Vic. 657.
BALFOUR, BEATTY & CO., LTD., 66 Queen St., E.C.4. T., City 503.
BELL, GEORGE, & SONS, LTD., 53 Bruce Grove Rd., N.17. T., Tottenham 32; T.A., Censorius, London.
BOLLOM, G., Horn Lane, Acton, W.3. T., Chiswick 201.
BOOT, HENRY, & SONS (LONDON), LTD., 12 Lower Grosvenor Place, S.W.1. T., Vic. 8325.
BOVIS, LTD., 41–44 Upper Berkeley St., W. T., Paddington 10.
BRAND, C., & SON, 188 West Regent St., Glasgow.
CAFFIN & CO., LTD., 25 Craven St., W.C.2. T., Central 1748.
CHESSUMS, LTD., Imperial Works, Portland Rd., N.15. T., Tottenham 1891.
CHIMNEYS, LTD., 47 Victoria St., S.W.1. T., Vic. 4700; T.A., Stablochim, Vic, London.
CHRISTIANI & NIELSEN, 72–74 Victoria St., S.W.1. T., Vic. 3565–6; T.A., Reconcret, Vic, London.
COCHRANE, JOHN, & SONS, LTD., 39 Victoria St., S.W. T., Vic. 4740. T.A., Estimate, Sowest, London.
COLUMBIAN FIREPROOFING CO., LTD., Windsor House, Victoria St., S.W.1. T., Vic. 4089; T.A., Cicadarum, Sowest, London. (*See p.* 245.)
CONCRETE PILING, LTD., 68–69 Windsor House, Victoria St., S.W.1. T., Victoria 4934; T.A., Pilkrete, Sowest, London. (*See p.* 274.)
CONSOLIDATED CONSTRUCTION CO., LTD., 9 Cloak Lane, E.C.4. T., City 8176; T.A., Solconstru, Cannon, London.
CULLUM, HORACE W., & CO., LTD., 50–2 Britannia St., W.C.1. T., Museum 1797; T.A., Kulmeo, Kincross, London. (*See p.* 246.)
EDWARDS CONSTRUCTION CO., LTD., 86A High St., Eltham, S.E.9. T., Lee Green 851; T.A., Lee Green 851.

Farr, Albert E., 8–10, Gt. St. Helen's, E.C.3. T., City 8459; T.A., Ghoorka, Stock, London.
Foster & Dicksee, Ltd., Manresa Rd., S.W.3. T., Kensington 1400.
Foundation Co., Ltd., 83 Kingsway, W.C.2. T., Regent 6370; T.A. Focotrapu, Westcent, London.
French, W. & C., Buckhurst Hill, Essex.
Galbraith Bros., Ltd., 63 Waterloo St., S.E.5. T., Hop. 1074.
Garrett, J., & Son, 83 Balham Hill, S.W.12. T., Streatham 1714.
Godson, G., & Sons, Ltd., Pembroke Works, Kilburn, W.10. T., Paddington 5770.
Greenwood, John, Ltd., 12 & 14 Arthur St., E.C.4. T., City 5144.
Hall, Beddall & Co., Ltd., Pitfield Wharf, Waterloo Bridge, S.E.1. T., Hop. 598; T.A., Pitfihall, London.
Higgs & Hill, Ltd., Crown Works, South Lambeth Rd., S.W.8. T., Brixton 2340; T.A., Higadillo, London.
Higgs, F. & H. F., Ltd., Station Works, Hinton Rd., Herne Hill, S.E. T., Brixton 165; T.A., Brixton, 165, London.
Hipperson, F. R., 2–4 Broad Street Place, E.C.2. T., London Wall 2715.
Holland & Hannen and Cubitts, Ltd., 258 Gray's Inn Rd., W.C.1. T., Museum 8330; T.A., Cubit, Kincross, London.
Holliday & Greenwood, Ltd., Stewart's Rd., S.W. T., Brixton 2880; T.A., Holliday Greenwood, Batt Park, London.
Holloway Bros. (London), Ltd., Bridge Wharf, Grosvenor Rd., S.W.1. T., Vic. 8560; T.A., Antefixa, Churton, London.
Holst, K., & Co., 1 Victoria St., S.W.1. T., Vic. 4234; T.A., Ferrolst, Sowest, London. (*See p.* 231.)
Humphreys, Ltd., Knightsbridge, S.W.7. T., Kensington 6447; T.A., Humphreys, Knightsbridge, London.
Huntington, F. D., Ltd., 11 Hanover Sq., W.1. T., Mayfair 7134; T.A., Effdehunti, Wesdo, London.
Industrial Constructions, Ltd., 44 Grosvenor Place, S.W.1. T., Vic. 6590; T.A., Refcreton, Phone, London. (*See pp.* 232–3.)
Jackson, D. T., 106 Ripple Rd., Barking. T., East Ham 113; T.A., Jackson, Barking.
Jackson, Sir John, Ltd., 53 Victoria St., S.W.1. T., Vic. 8649; T.A., Cofferdam, Sowest, London.
Jarvis, J., & Sons, Ltd., 8 Wormwood St., E.C.2. T., London Wall 1832; T.A., Jandess, Phone, London.
Jones, Walter, & Sons, 64 Victoria St., S.W.1. T., Vic. 6661.
Kirk and Randall, Ltd., 146–7 Grosvenor Rd., S.W.1. T., Vic. 2945; T.A., Vicrandic, Churton, London. (*See p.* 235.)
Lawrence, Walter, & Son, Ltd., 19 Finsbury Square, E.C.2. T., Clerkenwell 1467.
Leslie & Co., Ltd., St. James' House, Kensington Sq., W.8. T., Kensington 1257.
Lind, Peter, & Co., 2 Central Bldgs., Westminster, S.W.1. T., Vic. 3746; T.A., Inneloclin, Phone, London. (*See p.* 236.)
London Structural Co., Ltd., 1 Tudor St., E.C.4. T., City 1476; T.A., Londstruct, Fleet, London.
Lorden, W. H., & Son, Ltd., 107 Trinity Rd., S.W.17. T., Battersea 1035; T.A., Lorden, Wandscom, London.
Lovatt, Wilson & Sons, Ltd., Clarence St., Wolverhampton.
Lovell, Y. J., & Son, 6 Bathurst St., W.2. T., Paddington 920.
McAlpine, Sir Robert, & Sons, 50 Pall Mall, S.W.1. T., Gerrard 6754; **T.A.,** Ferrocrete, Piccy, London.
Maddison, W. J., Ltd., 124 Minories, E.1. T., Avenue 6281.
Minter, F. G., Ferry Works, S.W.15. T., Putney 1900.

Monk, A., Joinery Works, Lower Edmonton, N.9. T., Tottenham 98.
Monnoyer British Construction Co., Ltd., 6 New Burlington St., W.1. T., Gerrard 6977; T.A., Reyonnom, London. (*See p.* 237.)
Monolithic & General Constructions, Ltd., 7 Prince's St., S.W.1. T., Vic. 6487.
Mowlem, John, & Co., Ltd., 41 Ebury Bridge Rd., S.W.1. T., Vic. 3348; T.A., Mowlem, Sloane, London.
Muirhead, T., & Co., Ltd., Palace Chambers, Westminster, S.W.1. T., Vic. 1958; T.A., Daehrium, Parl, London.
Muirhead, W., McDonald, Wilson & Co., Ltd., 41 Parliament St., S.W.1. T., Vic. 537.
Parkinson, J., & Sons (Blackpool), Ltd., 171 Shaftesbury Ave., W.C.2. T., Regent 4587.
Patman & Fotheringham, Ltd., 15 Park St., N.1. T., North 551; T.A., Building, Nordo, London.
Pearson, S., & Son, Ltd., 10 Victoria St., S.W.1. T., Vic. 8930. T.A., Sonraep, Sowest, London.
Perry & Co. (Bow), Ltd., Victoria St., Westminster, S.W.1.
Price, John, & Son, 69 Victoria St., S.W.1. T., Vic. 4631.
Robinson, R., & Co., 11 Tothill St., S.W.1. T., Vic. 2641.
Roome, E. A., & Co., Ltd., 7 Urswick Rd., E.9. T. Dalston 280; T.A., Roome, Urswick Rd., E.9.
Saxild & Partners, 2 Central Bldgs., Westminster, S.W.1. T., Vic. 7271; T.A., Saxconcret, Phone, London. (*See pp.* 238–9.)
Scott, Walter, & Middleton, Ltd., 28 Victoria St., S.W.1. T., Vic. 1293; T.A., Dislodge, Vic, London.
Smith, J., & Sons (Norwood), Ltd., Junction Works, S. Norwood, S.E. T., Addiscombe; T.A., Smisurato, London.
Somerville, D. G., & Co., Ltd., 30 Grosvenor Place, S.W.1. T., Vic. 7818.
Speight, L. J., Ltd., Sardinia House, Kingsway, W.C.2. T., Holborn 1467; T.A., Steelcrete, Holb, London.
Stewart, J. & W., 12 Berkeley St., W.1. T., Mayfair 306; T.A., Cymplecks Piccy, London. (*See pp.* 247, 276.)
Stuart's Granolithic Co., Ltd., 63 Lincoln's Inn Fields, W.C.2. T., Holborn 5268; T.A., Granolith, Holb., London.
Thomas & Edge, 79 New Rd., Woolwich, S.E. T., Woolwich, 64; T.A., Tomarzedgra, London.
Topham, Jones & Railton, Ltd., 11 Great George St., S.W.1. T., Vic. 8913; T.A., Canal, Parl, London.
Topping & Leggat, 51 Tothill St., S.W.1. T., Vic. 5347; T.A., Smokechim, Vic. London. (*See p.* 241.)
Trollope & Colls, Ltd., 5 Coleman St., E.C.2. T., London Wall 4826; T.A., Trocoll, Phone, London.
Unit Construction Co., Ltd., 168 Regent St., W.1. T., Gerrard 1768; T.A., Uniconstru, Piccy, London.

Middlesex.—

Fairhead, Allen & Son, Sydney Rd., Enfield. T., 456; T.A., Fairhead, Enfield.

Norfolk.—

Hipperson, F. R., Norwich.
May, R. J., Trowse, Norwich. T., 1471; T.A., May, Trowse.
Shanks, F. W., Hunstanton. T., 46; T.A., Shanks, Hunstanton.

Northamptonshire.—

Thompson, J., & Sons, 43 Wood St., Peterborough. T., 35; T.A., Thompson, Peterborough.

Northumberland.—

Blackett's Construction Co., Ltd., Thornaby-on-Tees. T., 19; T.A., Ships, Stockton.
Brims & Co., Ltd., Pandon Bldgs., Newcastle-upon-Tyne. T., 3538; T.A., Brims, Newcastle-on-Tyne.
Easten, Stephen, Ltd., Milburn House, Newcastle. T., Central 2438.
Lumsden, T., Grantham Rd., Newcastle-upon-Tyne. T., Central 3202.
Scremerston Ferrocrete Construction Co., 9 Bridge St., Berwick-on Tweed. T., 42; T.A., Ferrocrete, Berwick-on-Tweed.

Nottinghamshire.—

Evans, F., & Sons, Highbury Works, Bulwell. T., 40.
Pillatt, G. A., & Son, 92A Sherwood St., Nottingham. T., 1612.
Rogers & Crooks, Ltd., Victoria St., Mansfield. T., 332.

Somersetshire.—

Hayward & Wooster, Walcot St., Bath. T., 69; T.A., Hayward, Bath.

Staffordshire.—

Godwin, T., & Son, Raymond St., Hanley. T., 168; T.A., Godwin, Builder, Hanley.
Hodges, Geo., & Son, Horninglow St., Burton-on-Trent. T., 296–7; T.A., Burton-on-Trent, 296.
Willcock, H., & Co., Darlington St., Wolverhampton. T., 259.

Suffolk.—

Evans, R. A., & Co., Ltd., St. Leonard Rd., Lowestoft. T., 432.

Surrey.—

Ball, A. H., & Co., Ltd., 1 South St., Farnham. T., 85; T.A., Ball, Farnham, 85.
Grace & Marsh, Ltd., 79 Tamworth Rd., Croydon. T., 1576.
Hardy, A., & Co., Kingsway Ave., Woking. T., 403.
Streeter, H., 59 Leslie Park Rd., Croydon. T., 1095; T.A., Streeter, Addiscombe.

Sussex.—

Barnes, J., & Sons, 99 & 100 North St., Brighton. T., Post Office 199; T.A., Barnes, P.O. 199, Brighton.

Warwickshire.—

Birmingham Concrete Steel Co., 125 Edmund St., Birmingham. T., Central 3273. (*See p.* 228.)
Hussey, Egan & Pickmere, 191 Corporation St., Birmingham. T., Central 6264; T.A., Yessuh, Birmingham.
Johnson, T., Great Brook St., Birmingham. T., East 278.
Lyne & Sons, Ltd., 50 Vaughton St., South Birmingham. T., Midland 1703.
Maddocks & Walford, Tyburn Rd., Birmingham. T., East 746; T.A., Straight, Birmingham.

PARNELL, J., & SON, Oliver St., Rugby. T., 19; T.A., Parnell, Rugby.
SAPCOTE, W., & SONS, 87 Camden St., Birmingham. T., Central 2269.
UNIQUE HOUSES, LTD., 109 Colmore Row, Birmingham. T., Central 2257.

WORCESTERSHIRE.—

LAW, G., Comberton Hill, Kidderminster. T., 61; T.A., Law, Kidderminster.
VALE, THOMAS, & SONS, LTD., Stourport. T., 62; T.A., Vale, Stourport.

YORKSHIRE.—

AIREY, WM., & SON, LTD., Greek St. Chbrs., Leeds. T., 21573; T.A., Duo, Leeds.
BIRCH, W., & SONS, LTD., Spen Lane, York. T., 782.
DYSON, JOHN E., Birkhouse, Crosland Moor, Huddersfield. T., 1127.
EDWARDS & CO. (DONCASTER), LTD., 1 St. Sepulchre Gate, Doncaster. T., 334; T.A., Concrete, Doncaster.
GRAHAM, A., & SONS, Longroyd Bridge, Huddersfield. T., 175.
KETTLEWELL, SONS, & CO., 11–13 Colonial St., Hull. T., 5193.
LEVITT, J. T., LTD., 84 Holderness Rd., Hull. T., Central 2640.
LOGAN & HEMINGWAY, 16 South Parade, Doncaster. T., 374; T.A., Avoiding, Doncaster.
LONGDEN, GEORGE, & SON, LTD., Parkwood Rd. Works, Neepsend, Sheffield. T., Central 4577. T.A., Longdenson, Sheffield.
MARSDEN, A. C., Ashfield Ave., Frizinghall, Bradford. T., Shipley 521.
NADIN, JOHN E., & SON, LTD., 206 Cobden View Rd., Sheffield. T., Broomhill 371.
PANTON, GEO. H., & SONS, LTD., 204 Anlaby Rd., Hull. T., Central 1623.
REID, ANDREW, & SONS, Lloyd's Bank Chbrs., Huddersfield. T., 1800; T.A., Aras, Huddersfield.
SANGWIN, LTD., Stepney Lane, Hull. T., Central 7976; T.A., Sangwin, Stepney Lane, Hull.
STANDARD CONSTRUCTION CO., Standard House, Cardigan Rd., Leeds. T., 20196; T.A., Asphalt, Leeds.
SUGDEN, H., & SON, Cornwall Rd., Manningham, Bradford. T., 6736.
WADDINGTON, A., & SON, 40 Carterknowle Rd., Sheffield. T., Sharrow 185; T.A., Aqueduct, Sheffield.
WELLERMAN BROS., LTD., 223 Attercliffe Rd., Sheffield. T., 2518; T.A., Wellerman, Sheffield, 2518. (*See p.* 243.)
WHITE, E. H., Pinfold, Brierley Wood, Huddersfield. T., 883.
WILKINSON, THOMAS, & SONS (BUILDERS), LTD., Olive Grove Works, Midhill Rd., Sheffield. T., Sharrow 391.
YORKSHIRE HENNEBIQUE CONTRACTING CO., LTD., Kirkstall Rd., Leeds. T., 20687; T.A., Ferro, Leeds.

SCOTLAND.—

ARROL, SIR WILLIAM, & CO., LTD., 85 Preston St., Bridgeton, Glasgow. T., Bridgeton 940; T.A., Tay, Glasgow.
BAILLIE, R., Pencaitland. T., 1.
BAIN & BROWN, LTD., 236 Leith Walk, Leith. T., 346. (*See p.* 226.)
CLARK & CHAPMAN, 57 Charlotte St., Aberdeen. T., 1433; T.A., Clark, Chapman, Aberdeen.
COWIESONS, LTD., 3 Charles St., St. Rollox, Glasgow. T., Bell 903–4; T.A., Bungalows, Glasgow.
DICK, CHARLES (SEN.), Dick St., Monifieth. T., 71.
DRYSDALE, J., 74 Bluevale St., Glasgow. T., Bridgeton 47.

Gilchrist, Robert, & Son, Ltd., 48 New St., Calton, Glasgow. T., Bridgeton 1236; T.A., Gilcrison, Glasgow.
Henderson, P. M., Selkirk St., Markinch. T., 18; T.A., Henderson, Builder, Markinch.
Inglis, John, & Son, 18 Prince's St., Kilmarnock. T., 278.
Kerr, W., Woodwynd, Kilwinning. T., 55; T.A., Kerr, Contractor, Kilwinning.
Kinnear, Moodie & Co., 219 St. Vincent St., Glasgow. T., Central 5626; T.A., Kinmoodie, Glasgow.
McBride, P., & Co., Ltd., 13 Chapel Lane, Port Glasgow. T., 31; T.A., Cement, Port Glasgow.
Meikle, J. & D., 44–46 Main St., Ayr. T., 161; T.A., Meikle, Builders, Ayr.
Muir, Matthew, & Co., Ltd., 6 Bank Place, Kilmarnock. T., 104.
Reid, G., & Son, Catrine, Ayrshire. T., Catrine 10; T.A., Reid, Heathfield, Catrine.
Rome, J., & Sons, Woodstock St., Kilmarnock. T., 227.
Sellar & Co., 116 John St., Aberdeen. T., 639.
Smith, G., & Sons, Dunnikier Rd., Kirkcaldy.
Street & Co., Townhill, Dunfermline. T., 283; T.A., Street, Townhill.
Thorburn, R., & Son, 137 Buccleuch St., Edinburgh. T., Central 676; T.A., Ferro, Edinburgh.
Wilson, Kinmond & Marr, Ltd., 4a Fairlie Park Drive, Partick, Glasgow. T., Western 2156; T.A., Earthwork, Glasgow.

Wales.—

Barnes, Chaplin & Co., Ltd., St. Peter St., Roath, Cardiff. T., 896; T.A., Spigot, Cardiff.
Calways, Ltd., Cwm Rd., Upper Strand, Swansea. T., Central 1633; T.A., Monolithic, Swansea.
Jordan, Ernest C., & Son, Harrow Rd., Newport, Mon. T., 3072; T.A., Adepts, Newport, Mon.
Julian, A. W., Bonvilston Building Yard, Pontypridd. T., 209; T.A., Julian, Pontypridd.
Lomas, J. W., & Co., Tresillian Terrace, Cardiff. T., 776; T.A., Apex, Cardiff.
Mackenna, Ltd., 28 Castle St., Swansea. T., Docks 507; T.A., Mackenna, Swansea.
Penarth Concrete Co., Ltd., Lower Penarth. T., Penarth 5; T.A., Reinforced, Penarth.
Scott, Andrew, Port Talbot. T., 42; T.A., Scott, Contractor, Port Talbot. (*See p.* 240.)
Seaton, Pontypridd. T., 108; T.A., Seaton, Pontypridd.
South Wales Contractors, Ltd., Pembroke Bldgs., Swansea. T., Docks 2702; T.A., Industry, Swansea.
Stow, George, & Co., Ltd., Station Chbrs., Cambrian Rd., Newport. T., 2651; T.A., Cofferdam, Newport, Mon.
Tucker Bros., 181 & 183 Broadway, Cardiff. T., 2447.
Watkin Williams & Sons, Llanishen, nr. Cardiff. T., Llanishen, Cardiff, 96.

Ireland.—

Campbell, W. J., & Son, Ravenhill Rd., Belfast. T., 491; T.A., Campbells, Contractors, Belfast.
Collen Bros., Ltd., Portadown, Co. Armagh. T., 49.
Costen, P., & Son, Waterford. T., 126.
Delany, John, & Co., 25 Henry St., Cork. T., 359; T.A., Delany, Builder, Cork.

HENRY, JAMES, & SONS, Crumlin Rd., Belfast. T., 237; T.A., Henry, 237, Belfast.
HOGG, JAMES, & SON, LTD., Baroda St., Belfast. T., 2524; T.A., Excavator, Belfast.
ROME, GEO., & CO. (DUBLIN), LTD., 60 Mespil Rd., Dublin. T., Ballsbridge, 656; T.A., Cornice, Dublin.
THOMPSON, J. & R., Ltd., 128 Roden St., Belfast. T., 804; T.A., Thompson, 804, Belfast.
THORNBURY BROS., LTD., Ravenhill Rd., Belfast. T., 1773.

FLOORING CONTRACTORS.

BAIN & BROWN, LTD., 236 Leith Walk, Leith. T., 346. (*See p.* 226.)
COLUMBIAN FIREPROOFING CO., LTD., Windsor House, Victoria St., S.W.1. T., Vic. 4089; T.A., Cicadarum, Sowest, London. (*See p.* 245.)
CULLUM, HORACE W., 50–52 Britannia St., W.C.1. T., Museum 1797; T.A., Kulmco, Kincross, London. (*See p.* 246.)
DIESPEKER & CO., LTD., 57–60, Holborn Viaduct, E.C.1. T., Holborn 1027; T.A., Imperishable, Cent, London.
FAWCETT CONSTRUCTION CO., LTD., 65 Victoria St., S.W.1. T., Vic. 5845–6; T.A., Abednego, Sowest, London.
FRAM REINFORCED CONCRETE CO., LTD., 37 Princess St., Manchester. T., City 4128–9; T.A., Mimosa, Manchester.
HOMAN & RODGERS, 17, Gracechurch St., E.C.3.
KLEINE PATENT FIRE RESISTING FLOORING SYNDICATE, LTD., 133–136 High Holborn, W.C.1. T., Museum 5328; T.A., Soundproof, London.
LONDON STRUCTURAL CO., LTD., 1 Tudor St., E.C.4. T., City 1476; T.A., Londstruct, Fleet, London.
MONOLITHIC & GENERAL CONSTRUCTIONS, LTD., 7 Princes St., S.W.1. T., Vic. 6487; T.A., Monogena, Phone, London.
MUSKER, C., BROS., LTD., New Cross St., Manchester. T., Eccles 209.
PEARSON BROS. & CAMPBELL, LTD., 24 Chapel St., Liverpool. T., Bank 3584; T.A., Keystone, Liverpool.
SIEGWART FIREPROOF FLOOR CO., LTD., 231 Strand, W.C. T., City 9546; T.A., Nocentring, Estrand, London.
SOMERVILLE, D. G., & CO., LTD., 30 Grosvenor Pl., S.W.1. T., Vic. 7818.
STEWART, J. & W., 12 Berkeley St., W.1. T., Mayfair 306; T.A., Cymplecks, Piccy, London. (*See pp.* 247–76.)
STUART'S GRANOLITHIC CO., LTD., 63 Lincoln's Inn Fields, W.C.2. T., Holborn 5268; T.A., Granolith, Holb, London.
VERDURA HARD COURT CO., Derwent Chambers, Derby. T.A., Verdura, Derby. (Green tennis courts; coloured floors.) (*See p.* 250.)
WARD, B., & CO., 9 Dumfries Pl., Cardiff. T., 2075; T.A., Tufa, Cardiff.

MACHINERY AND PLANT.

(T = Telephone Number; T.A. = Telegraphic Address. The nature of the plant supplied by each firm is given in brackets.)

ALEXANDER, HERBERT, & Co., LTD., 1 Charmouth St., Leeds. T., 23274; T.A., Alexson, Leeds. (Brick-making plant; mixers; crushers; elevators; conveyors). (*See p.* 254.)

ALLIED MACHINERY CO., LTD., 70 Victoria St., S.W.1. T., Vic. 1813–4; T.A., Alydmachin, Sowest, London. (Mixers and pavers; road-finishing machines; steel road forms; chuting plant; carts and barrows; radial gate hopper cars; bottom dump buckets; batch boxes; portable conveyors.) (*See pp.* 252–3.)

ATLAS DIESEL CO., LTD., 35 Surrey St., W.C.2. T., Central 9067; T.A., Dieselmot, Estrand, London. (Air compressors; rock drills; mining and quarry machinery; drill steel sharpening machines; air hoists; air motors; air locomotives; air valves, cocks, regulators; pipe and hose couplings; rock drill steels; plain and armoured hose; crude oil and Diesel engines.) (*See p.* 255.)

"AUSTRALIA" CONCRETE MACHINERY AND ENGINEERING CO., LTD., Pordon Rd., S.W. T., Brixton 3296; T.A., Auscon, Brix, London. (Mixers; hand and power block-making machines; crushers; steel barrows and trucks.)

BAXTER, W. H., LTD., 71 Gelderd Rd., Leeds. T., 25574; T.A., Knapping, Leeds. (Stone-breakers; stone and sand washers and driers; granulating machinery; elevating and screening plant.)

BERRY, HENRY, & Co., LTD., Croydon Works, Hunslet, Leeds. T., 20181–20182; T.A., Rivetter, Leeds. (Hydraulic paving flags and block machines.)

BLUNN, J., Park Works, Carver St., Old Trafford, Manchester. T., Trafford Park 599. (Concrete-block hand moulds.)

BOOTH & BROOKES, LTD., Mildmay Iron Works, Burnham-on-Crouch. T., 9; T.A., Booth, Burnham-on-Crouch. (Cast-iron moulds for posts; crazy work paths; kerbs; pallets.)

BOOTHROYD, H. T., LTD., Bootle, Liverpool. T., Bootle 420; T.A., Commutator, Liverpool. (Hand block-making machines.)

BRADSHAW'S REINFORCED CONCRETE CO., LTD., 87 Windsor House, Victoria St., S.W.1. T., Vic. 8870. (Power-driven moulding machines.) (*See pp.* 278–9.)

BRITISH LÉAN CO., LTD., 11 Suffolk St., S.W.1. T., Gerrard 846; T.A., Ulléanwal, Piccy, London. (Block-making machines.)

British Steel Piling Co., Dock House, Billiter St., E.C.3. T., Avenue 5463; T.A., Pilingdon, Fen, London. (Mixers; chuting plants; piling plant; winches; pile frames; driving hammers; jacks.) (*See pp.* 272–3.)

Builders & Contractors Plant, Ltd., 51 Tothill St., S.W.1. T., Vic. 5347. (Mixers; hoists and cranes; tipping wagons, skips, crushers; screens; sand washers; chuting plant; light railways.)

Building Products, Ltd., 44–6 King's Rd., S.W.3. T., Vic. 2590; T.A., Bylprodia, Sloane, London. (Bolt-hanger sockets; slotted inserts.) (*See p.* 304.)

Byrd, A. A., & Co., 11 Queen Victoria St., E.C.4. (Mixers; pavers; bar benders and cutters; "Metaform" interlocking steel forms; road rail forms; steel forms for manholes and sewers; adjustable shores for concrete floors; crane excavators and hoists.) (*See pp.* 256–8.)

Cement Industries, Siddals Rd., Derby. T.A., Cementin, Derby. (Floor-finishing machine.) (*See p.* 251.)

Chalmers-Edina Co., 39 Assembly St., Leith. T., Leith 817; T.A., Deluge, Leith. (Mixers; petrol-driven hoists.) (*See p.* 259.)

Christmas and Walters, Ltd., Caxton House, Westminster, S.W.1. T., Vic. 9350; T.A., Inasmuch, Parl, London. ("Blawforms.")

Climbing Steel Shuttering Co., 515 Queens Rd., Sheffield.

Concrete Machinery Co., 24 Chapel St., Liverpool. T., Bank 3584; T.A., Keystone, Liverpool. (Block-making machines; mixers.)

Coneybeare, J., & Co., 89–91 Church St., S.E.10. T., Greenwich 821; T.A., Coneybeare, Greenwich. (Pipe-making machines; pipe moulds.)

Cowan Hulbert, 423 Abbey House, Victoria St., S.W.1. T., Vic. 8938; T.A., Snugly, Sowest, London. (Distributing plant.) (*See p.* 260.)

Cummings, C. B. 3 Waller Rd., S.E.14. (Bar cutters and benders.)

Cyclops Concrete Co., 9–11 Hilbre St., Liverpool. T., Royal 1195; T.A., Assessor, Liverpool. (Mixers for hand or power; block machines; fence-post machines; tile machines; brick machines; moulds for drain tiles, balusters and gate piers.) (*See p.* 261.)

Drummond Bros., Ltd., Ashdale, Guildford. T., 153; T.A., Lathes, Stoughton. (Mixers; diaphragm pumps; force pumps.)

Fawcett, J. Dawson, (Darlington), Ltd., Haugton Works, Darlington. T., 2293; T.A., Fawcett, Darlington. (Power mixers; elevators; screens.)

Fielding & Platt, Ltd., Atlas Works, Gloucester. T., 58 & 826; T.A., Atlas, Gloucester. (Hydraulic paving slab presses.)

Fowler, John, & Co. (Leeds), Ltd., Hunslet, Leeds (T., 21641–2; T.A., Fowler, Leeds); and 113 Cannon St., E.C.4 (T., City 6508–9; T.A.) Steamplow, Cannon, London). (Mixers; chuting plant; stone-breakers., (*See p.* 262.)

GASTON, LTD., Larden Rd., W.3. T., Chiswick 2180; T.A., Gastonorge, Act, London. (Mixers and pavers.)

GIBBINS, RICHARD C., & Co., Berkley St., Birmingham. T., Midland 244; T.A., Gibbins, Birmingham. (Cranes; hand pile drivers; sheer legs; winches; bar benders.)

GILCHRIST, ALEXANDER, 25 Eglinton St., Glasgow. T.A., Grooves, Glasgow. (Brass rollers for cement and artificial paving.) (*See p.* 263.)

GOODWIN, BARSBY & Co., LTD., St. Margaret's Ironworks, Leicester. T., Central 2134; T.A., Goodwin, Ironfounder, Leicester. (Mixers, hand and power; hand block-making machines; pipe moulds; crushers; washers; screens.)

HAMILTON, H. & A., Thomas St., Waterford. T., 314; T.A., Hamilton. Waterford. (Hand block and slab-making machine and brick-making attachment.)

HARTLEY, LTD., Lode, Cambridge. T., 266; T.A., Hartley, 266, Cambridge. (Hand slab, block and brick-making machines.)

HOPKINS, W., Leonard Stanley, Glos. (Block-making machines; shuttering.)

INGERSOLL RAND CO., LTD., 165 Queen Victoria St., E.C.4. T., City 3852; T.A., Ingersoll, Cent, London. (Cement gun.)

JOHNSON, B., & SON, Wharfedene, Skipton Rd., Ilkley. T.A., Wharfedene, Ilkley. (Contractors' plant.)

KENNEDY, W., Station Works, West Drayton, Middlesex. T., Yiewsley 84; T.A., Kennedy, West Drayton, Middlesex. (Bar-bending machines.)

KIRK, R. H., & Co., Newcastle-upon-Tyne. T., Central 1915; T.A., Kirks, Newcastle-upon-Tyne. (Head and sill machines; hand partition slab and block machines; mixers; mechanical tampers; kerb and channel machines; concrete flag moulds.)

LEWIS & LEWIS, LTD., Townmead Rd., S.W.6 T., Putney 521. (Mixers, hand and power.)

LIDGERWOOD, LTD., Friars House, New Broad St., E.C. T., London Wall 7422; T.A., Lidgerwood, London. (Hoists; derricks; piling hammers and drivers; cableways.)

LINER CONCRETE MACHINERY CO., Newcastle-upon-Tyne. T., Central 256; T.A., Screens, Newcastle. (Block-making machinery; artificial stone-moulding machinery; sand and gravel-washing screening plants.)

"MANELITE" PATENT CONCRETE MACHINERY CO., LTD., 61 Poole Hill, Bournemouth. T., 1060; T.A., Manelite, Bournemouth. (Hydraulic; and hand) block-making machines; hydraulic post machine-power; mixers; hand brick machine.)

MASON BROS., Brandon St., Leicester. T., 1158; T.A., Breaker, Leicester. (Stone-breaking and grinding machines; mixers; screens.)

MILLARS' TIMBER & TRADING CO., LTD., Pinners' Hall, E.C.2. T., London Wall 368; T.A., Jarrah, Stock, London. (Mixers, hand and power; chuting plant; rock crushers; carts and wheelbarrows; saw benches for shuttering; pumps; pile hammers.)

PARKER, WINDER & ACHURCH, LTD., Broad St., Birmingham. T., Mid. 2940; T.A., Ironclad, Birmingham. ("Empire" mixers, hand or power.) (*See p.* 264.)

PATENT LIGHTNING CRUSHER CO., LTD., 14A Rosebery Ave., E.C.1. T., Clerkenwell 6298; T.A., Agenciador, London. (Crushers and pulverisers.)

PATERSON, HUGHES ENGINEERING CO., LTD., 36 Charlotte Lane, Glasgow. T.A., Zenith, Glasgow. (Conveyors.)

PATON, J. K., 64 Princes St., Perth. T. 44. (Block-making machine.)

PERFECT CONCRETE MIXER CO., Broxbourne. T., 60; T.A., Rikof, Broxbourne. (Washing and grading machines; mixers.)

PRICE, FRANK G., & CO., Avenue Works, Carmyle, Glasgow. T., Shettleston 125; T.A., Limpet, Glasgow. (Power consolidating machines.)

RANSOME MACHINERY CO. (1920), LTD., 14–16 Grosvenor Gardens, S.W.1. T., Vic. 8060; T.A., Ransomaco, Sowest, London. (Mixers; moulding machine; placing plant; steel sheet piling; piling plant; winches; hoists; capstans; windlasses; steel hand tip-carts.) (*See p.* 265.)

SIDE GROOVE STEEL PILING SUPPLY CO., LTD., 17 Victoria St., S.W.1. T., Vic. 1325; T.A., Sidropud, Sowest, London. (Steel piling; pile-driving hammers and equipment; hand or power cement grouting pumps; winches; pile shoes.)

SMEDLEY BROS., LTD., Eagle Iron Works, Belper, Derbyshire. T., Belper 12; T.A., Smedleys, Belper. (Grinding mills; mixers.)

SMITH, T. L., CO., THE, 13 Victoria St., S.W.1. (Mixers, hand and power; crushers; screens; gravel washers; drag-line excavators.)

STANDARD CONCRETE MACHINE CO., 317 High Holborn, W.C.1. T., Holborn 1875. (Block-making machines.)

STOTHERT & PITT, LTD., Bath. T., 987 & 988; T.A., Stothert, Bath. (Mixers; road-making plant; chuting plant; plant for casting concrete pipes; concreting plant for large dams and reservoirs complete with self-contained hoppers; hand block-making machines.) (*See pp.* 266–7.)

TRIANGULAR CONSTRUCTION CO., LTD., Imber Court, East Molesey, Surrey. T., Esher 341; T.A., Triangular, East Molesey. (Hand power partition slab machines; hand power triangular block machines; "Trianco" process.)

VICKERS, LTD., Weybridge Works, Weybridge. T., Byfleet 240; T.A., Vickers, Weybridge. (Brick-making machines; roofing-tile machines; slab machines; mixers; all portable hand machines.)

WALLER, G., & SON, LTD., Phœnix Iron Works, Stroud, Glos. T., Brimscombe 10; T.A., Waller, Brimscombe. (Mixers, hand and power; block-making machinery.)

WEST, H. J., & Co., LTD., 72–74 Gray's Inn Rd., W.C.1. T., Holborn 5430; T.A. Frigify, Holb, London. (Mixers; block-making machines.)

WHITAKER, R. G., LTD., Ceres Rd., Kingston-on-Thames. T., 1131; T.A., Whitakers, Engineers, Kingston. (Slab and block-making machines; brick-making machines; mechanical tampers.)

WILDE, HENRY, & Co., 66 Victoria St., Westminster, S.W.1. T., Vic. 8960; T.A., Utilissand, Sowest, London. (Washers; screens; moulding machines.)

WINGET, LTD., Winget House, Grosvenor Gdns., S.W.1. T., Vic. 8334–5; T.A., Wingetism, Phone, London. (Crushers and crushing rolls; mixers; block-making machines, hand and power; roofing-tile machines; pavement slab outfit; portable elevators.) (*See pp.* 268–9.)

WOOD, HUGH, & Co., LTD., 65 Fenchurch St., E.C.3. T., Avenue 1545; T.A., Huwod, Fen, London. (Pulverisers; fixed and portable conveyors; elevators; portable loaders.)

WOOLLARD, J., 25 Elmfield Rd., E.17. T., Dalston 3283; T.A., Snow, Roseberry Foundry, Dalston. (Hand block and slab-making machines.)

WRIGHT, S., & Co., 57 Sanvey Gate, Leicester. T., 1228. (Slab machine.)

WYLIE, MATTHEW, & Co., LTD., 81 Portman St., Kinning Park, Glasgow. T., South 1635; T.A., Parallel, Glasgow. (Hand block-making machine; ornamental moulds.)

MOULD OIL.

LEEDS OIL AND GREASE Co., Leeds. T., 22480; T.A., Grease, Leeds.

WHITSON & Co., 104 West George St., Glasgow. T.A., Whitson, Glasgow. (*See p.* 270.)

PAINTS FOR CEMENT.

TOCH BROS., 74 Vicarage Lane, E.15. T., Maryland 1589; T.A., Cemenflor, Strat, London. (*See p.* 271.)

PILING CONTRACTORS AND MANUFACTURERS OF PILE-DRIVING PLANT.

BEVIS, FRANK, LTD., Portsmouth. T., 3288; T.A., Frank Bevis, Portsmouth. (*See p.* 227.)

BRITISH STEEL PILING Co., Dock House, Billiter St., E.C.3. T., Ave. 5463; T.A., Pilingdon, London. (Piling plant; pile frames; hammers.) (*See pp.* 272–3.)

CHRISTIANI & NIELSEN, 72–74 Victoria St., S.W.1. T., Vic. 3565–6; T.A., Reconcret, Sowest, London. (Concrete piles, to order only.)

CONCRETE PILING, LTD., Windsor House, Victoria St., S.W.1. T., Vic. 4934; T.A., Pilkrete, Sowest, London. (*See p.* 274.)

CONSIDÈRE CONSTRUCTIONS, LTD., 72 Victoria St., S.W.1. T., Vic. 3033; T.A., Spiralette, Sowest, London.

HOLMES, JOHN, & SONS, Whitchurch-on-Thames. T.A., Holmes, Whitchurch, Reading. (Shoes, distance pieces, and tie-bolts for concrete piles.)

JONES, WALTER, & SONS, 64 Victoria St., S.W.1. T., Vic. 6661.

LIDGERWOOD, LTD., Friars House, New Broad St., E.C. T., London Wall 7422; T.A., Lidgerwood, London. (Steam pile hammers; pile drivers.)

MILLARS' TIMBER & TRADING CO., LTD., Pinner's Hall, E.C.2. T., London Wall 368; T.A., Jarrah, Stock, London. (Pneumatic pile hammers.)

RANSOME MACHINERY CO. (1920), LTD., 14–16 Grosvenor Gdns., S.W.1. T., Vic. 8060; T.A., Ransomaco, Sowest, London. (Steel sheet-piling; piling plant.) (*See p.* 265.)

RICHARDS, W., & SONS, LTD., Britannia Foundry, Middlesbrough. T., 10; T.A., Richards, 10, Middlesbrough. (Cast-iron chill-hardened pile-shoes.)

SIDE GROOVE STEEL PILING SUPPLY CO., LTD., 17 Victoria St., S.W.1. T., Vic. 1325; T.A., Sidropud, Sowest, London. (Steel piling; pile-driving hammers and equipment; pile shoes.)

SIMPLEX CONCRETE PILES, LTD., 104 Victoria St., S.W.1. T., Vic. 541; T.A., Simpileseo, Sowest, London. (*See p.* 275.)

SOMERVILLE, D. G., & CO., LTD., 30 Grosvenor Place, S.W.1. T., Vic. 7818.

STEWART, J. & W., 12 Berkeley St., W.1. T., Mayfair 306; T.A., Cymplecks, Piccy, London. (Raymond piles.) (*See p.* 276.)

WHITAKERS (ENGINEERS), LTD., Horsforth, Leeds. T., Horsforth 23A; T.A., Excavators, Leeds. (Pile driving plant; steam hammers; winches.)

PRODUCTS.

(See also "Architectural Cast Stone and Paving Slabs," p. 149.)

(*T. = Telephone Number; T.A. = Telegraphic Address. The nature of the products made by each firm is given in brackets. Except where otherwise stated, the products mentioned are kept in stock.*)

BEDFORDSHIRE.—

BEDFORDSHIRE TILE CO., LTD., Grovebury Works, Leighton Buzzard. ("Bedfordshire" interlocking roofing tiles.) (*See p.* 277.)

GRANGE TILE WORKS, Ampthill. T., Lee Green, Beds., 205; T.A., Ampthill, Beds. (Roofing tiles; fencing posts.)

Leighton Buzzard Concrete Co., Tower Works, Leighton Buzzard. T., 60; T.A., 60, Leighton Buzzard. (Paving slabs; fence posts; kerbs and channels.)

Berkshire.—

Wait, E., North End, Newbury. T., Highclere 1Y4; T.A., Wait, Woolton Hill. (Rick stands; fence posts; kerbs and channels; edging tiles; balustrades; lintels; heads and sills; troughs; cisterns; paving and partition slabs.) (*See p.* 242.)

Wallingford Concrete Brick & Tile Works, 12–13 St. Martin's St., Wallingford. T., 9; T.A., William Honeybone, Wallingford. (Bricks; roofing tiles; blocks; kerbs and channels; lintels; breeze partition slabs; fixing bricks.)

Cambridgeshire.—

Atlas Stone Co., Ltd., Coldhams Lane, Cambridge. T., 230; T.A., Atlas, Cambridge. (Paving slabs; kerbs; channels; fence posts; heads, sills and steps.)

Cambridge Artificial Stone Co., Ltd., Corporation Sidings, Mill Rd., Cambridge. T., 1275; T.A., Hartley, 1275, Cambridge. (Breeze partition slabs; breeze fixing bricks; blocks, sills and heads; copings; fence posts.)

Tidnams, Ltd., 25 Market Pl., Wisbech. T., 187; T.A., Tidnams, Wisbech. (Reinforced fence posts.)

Channel Islands.—

Jersey Granite & Concrete Co., Ltd., Ronez Quarries, Jersey. T., St. John's 9; T.A., Granite, Jersey. (Wing blocks; corner blocks; hollow blocks; paving slabs. Window heads, sills, and mullions, made to order only.)

Cheshire.—

Bonsall, S. H., Railway Works, Cheadle Heath, Stockport. T., 2298; T.A., Bonsall, Stockport, 2298. (Kerb and channel; coping; paving flags; fence posts; slabs; blocks; fixing bricks; cable covers.)

Cornwall.—

Central Cornwall Concrete and Artificial Stone Manufacturers, Bugle. T., Stenalees 39; T.A., Concrete, Bugle. (Blocks; reinforced fencing posts; balusters; coping; general products.)

Cumberland.—

Forbes, W., 1 Brisco Mount, Egremont. (Blocks; slabs; heads and all other units. Reinforced work. To order only.)

Derbyshire.—

Cement Industries, Siddals Rd., Derby. T.A., Cementin, Derby. (Safes; stucco slabs; marble slabs; name plates; letters and signs; statuary.) (*See pp.* 282–5.)

Evans Bros., Riddings, Alfreton. T., Riddings 3. (Fencing posts; sills; heads; steps; kerbing; ridge and hip tiles; flags; troughs; tanks; garden frames and edging.) (*See p.* 291.)

Mosley, R., Chelmorton, Buxton. (Heads, sills, blocks, etc., to order only.)

Devonshire.—

Heywood, G., & Sons, Ltd., Queen St., Exeter. T., 193. (Partition slabs; concrete blocks; fence posts.)

Lax, Clifford, & Sons, Coombe Valley Works, Teignmouth Rd., Torquay. (Sectional concrete buildings; any concrete goods except sewer pipes.)

TEIGN VALLEY GRANITE CO., LTD., Trusham, Chudleigh. T., Chudleigh 15; T.A., Granite, Chudleigh. (Blocks; paving slabs; fence posts; tennis posts; lintels; sills; sectional pigsties; poultry houses; cow stalls; outbuildings; garden rollers.)

WILTSHIRE, L. J., Babbacombe Quarries, Torquay. T. 776. (Blocks.)

DORSETSHIRE.—

HANSFORD & HANSFORD, Lyme Regis. T.A., Hansfords, Lyme Regis. (Posts; blocks; quoins; slabs. To order only.)

SHARP, JONES & CO., LTD., Bourne Valley Works, Parkstone. T., Bournemouth 406; T.A., Henry, Bournemouth. (Sewer tubes—circular and egg-shape; low-pressure water pipes; sewer manholes; road gullies; well linings; tanks for water and sewage; roofing tiles.)

DURHAM.—

STOCKTON STONE & CONCRETE CO., LTD., Norton, Stockton-on-Tees. T., Norton 40; T.A., Concrete, Stockton-on-Tees. (Flags and kerbs.)

GLOUCESTERSHIRE.—

BRISTOL CONCRETE CO., LTD., Backwell, Bristol. T., Flax Bourton 47; T.A., Backwell, Bristol. (Blocks; partition slabs; tubes; posts; kerb; moulded work in colour; floor slabs.) (*See p.* 280.)

GLOUCESTER CONCRETE CONSTRUCTION CO., LTD., Hempstead, Gloucester. T., 984; T.A., Ferroship, Gloucester. (Blocks; sills; heads; architectural dressings.) (*See p.* 292.)

HOPKINS, W., Leonard Stanley, Glos. (Kerbs; fencing; paving; pre-cast culverts. For county requirements only.)

HOPTON, T. W., & SONS, 56 Franklyn St., St. Paul's, Bristol. (Partition slabs; breeze slabs; bricks.)

HAMPSHIRE.—

BEVIS, FRANK, LTD., Portsmouth. T., 3286; T.A., Frank Bevis, Portsmouth. (Concrete piles; blocks; partition slabs.) (*See p.* 227.)

BRADSHAW, E., & SON, 322 Fawcett Rd., Portsmouth. T., 4506. (Paving slabs; kerbs; channels.)

HALL, T. P., Ferrumite Works, Copnor, Portsmouth. T., 2872. (Paving; blocks; breeze partition slabs; fence and gate posts; staircases and landings; window and door heads; window sills; roofing tiles; copings and cornices.)

STRONCRETE MANUFACTURING CO., LTD., St. Clement's Rd., Bournemouth. T., 849; T.A., Stroncrete, Bournemouth. (Slabs; gate and fence posts.)

HEREFORDSHIRE.—

OLD RADNOR TRADING CO., LTD., Kington. T., Kington 11; T.A., Or, Kington. (Fence and gate posts; blocks; sills; heads; quoins; tanks; troughs.)

HERTFORDSHIRE.—

AIR AND WATER CONCRETE CO., LTD., 39 South St., Bishop's Stortford. (Blocks; partition slabs; bricks; roofing tiles.)

ALBAN BUILDING BLOCK MANUFACTURING CO., LTD., Watson's Walk, St. Albans. T., 506. (Breeze partition blocks.)

HUNTINGDONSHIRE.—

ALLEN, A. W., & SON, Fenstanton, St. Ives, Hunts. (Blocks and partition slabs to order only.)

Kent.—

Aisher, O., Marley Rd., Harrietsham. T., Lenham 28; T.A., Aisher, Harrietsham. (Breeze blocks; roofing tiles.)

Concrete Units, Strood Dock, Rochester. T., Chatham 284; T.A., Concrete Units, Chatham, 284. (Blocks; partition slabs; coping; steps; heads and sills; kerb and channel; fence and gate posts.)

Elmslie, R., & Co., Fant Quarries, Maidstone. T., 437; T.A., Fantquar, Maidstone. (Partition and paving slabs; fence posts; kerbing; blocks. Sills and lintels to order only.)

Fortescue, A. J., Smeeth, nr. Ashford. T., Willesborough 20Y4; T.A., Fortescue, Smeeth. (Blocks; partition slabs.)

Lancashire.—

Bethell, S., 18 Cornwall St., Openshaw, Manchester. T., Openshaw 185. (Breeze partition slabs; blocks.)

Christie Patent Stone Co., Ltd., Christie Rd., Stretford, Manchester. T., Trafford Park 19.

Concrete Unit Co., Ltd., Trafford Park, Manchester. T., Trafford 27; T.A., Conucoy, Manchester. (Fence posts; steps; artificial stonework.)

Fleetwood Granite Co., Ltd., Copse Rd., Fleetwood. T., 525; T.A., Granite Co., Fleetwood. (Blocks; paving slabs; kerbs; steps and landings. Artificial stone to order only.)

Fram Reinforced Concrete Co., Ltd., 37 Princess St., Manchester. (Partition slabs; steps; heads; sills.)

Gorse Hall Construction Co., Ltd., Gorse Hall, Chorley. T., Chorley 280. (Blocks; tiles; posts; hollow floors; steps; landings; heads and sills; stairs.)

Johnson, J. B., & Co., 108 Crown St., Liverpool. T. Royal 5133. (Partition slabs. Steps, heads and sills to order only.)

Lancashire Brunswick Rock Asphalt Co., Ltd., 51 Chorlton St., Manchester. T., City 3355. (Granolithic steps, to order only.)

Lee, J. W., & Co., Cowling Concrete Works, Chorley. T. 122; T.A., Jewel, Chorley. (Blocks; partition slabs; heads; sills.)

Liverpool Artificial Stone Co., Ltd., Picton Rd., Wavertree, Liverpool. T., Wavertree 1030; T.A., Breslabs, Liverpool. (Paving flags; breeze partition slabs; garden edging. Steps, heads, sills, lintels, copings, beams, etc., to order only.) (*See p.* 297.)

Morton, B., & Sons, 78 Quay St., Manchester. T., Central 5078; T.A., Metabric, Manchester. (Road slabs, to order only.)

Patteson, J. & H., 96 Oxford Rd., Manchester. T., Central 1201; T.A., Patteson, Manchester. (Terrazzo pavements; staircases; wall linings; slabs; steps.)

Pearson Bros. & Campbell, Ltd., 24 Chapel St., Liverpool. T., Bank 3584; T.A., Keystone, Liverpool. (Moulded dressings to order; paving slabs from stock.)

Pritchard, Hugh, & Sons, Canal Bank, Bootle. T., 994; T.A., Pritchard, Bootle. (Partition slabs; blocks; steps; floors.)

Warrington Concrete & Plaster Co., Ltd., 80A Liverpool Rd., Warrington. T., 481. (Blocks; posts; partition slabs; flags; manholes; gullies.)

Whitaker & Clegg, Ltd., 76 Manchester Rd., Burnley. T., 189. (Liquid manure tanks; boskin sides and troughs for farms.)

Leicestershire.—

Cliffe Hill Granite Co., Ltd., Cliffe Hill Granite Quarries, Markfield. T., Coalville 32; T.A., Cliffe, Markfield. (Artificial stone paving.)

CONSTONE, LTD., Narborough Rd. Sidings, Danvers Rd., Leicester. T., Aylestone 82; T.A., Constone, Leicester. (Paving and partition slabs; dressings; reinforced fence posts; kerb and channel.)

CROFT GRANITE, BRICK & CONCRETE CO., LTD., Croft, nr. Leicester. T., Narborough 13; T.A., Adamant, Croft, Leicestershire. (Paving slabs; kerbs and channels; armoured and unarmoured tubes; manholes; fencing, sign, lamp and line posts; gas and water indicator posts; gas-stove bases; cellwork for H.T. electrical switchgear; centreless floors and flat roofs; architectural stonework.)

WATCHORN, H. D., New Queniboro', Syston. T., Syston 61; T.A., Concrete Specialities, New Queniboro'. (Building blocks; roofing tiles.)

LINCOLNSHIRE.—

LILL, HENRY, Drummond Rd., Skegness. T., 115; T.A., Lill, Skegness, 115. (Pipes, posts, beams, copings, sills, heads, lintels, steps, kerbs, channels, paving flags, surrounds for steel windows, pillars, chimney blocks, strings and mouldings, blocks.) (*See p.* 293.)

LINDUM STONE CO., 85 Canwick Rd., Lincoln. (Dressings, tracery windows, garden ornaments, to order only.) (*See pp.* 294–5.)

LUDA CONCRETE PRODUCTS, LTD., Eve St., Louth. T., 26; T.A., Thompsons, 26, Louth.

LONDON.—

BAMBER, A. K., 32 Belmont Hill, Lewisham, S.E. (Green tennis courts with inlaid white lines.)

BATEMAN'S CONCRETE WORKS, LTD., 102 Victoria St., S.W.1. T., Vic. 9488; T.A., Franbate, Sowest, London. (Breeze slabs.)

BEACHCROFT CONCRETE CO., LTD., Beachcroft Works, E.11. T., Maryland 2984. (Partition slabs; blocks.)

BLAIR & SKARDON, Mayo Rd., N.W.10. T., Willesden 2957. (Partition slabs; blocks.)

BRADSHAW'S REINFORCED CONCRETE CO., LTD., Windsor House, Victoria St., S.W.1. T., Vic., 8870. (Telegraph posts; electric light standards; tramway poles; fence posts. To order only.) (*See pp.* 278–9.)

CONCRETE BLOCKS, LTD., 1 Church St., Chelsea, S.W. T., Kens. 7792. (Partition slabs; bricks. Hollow blocks, to order only.)

CONCRETE INDUSTRIES, LTD., 317 High Holborn, W.C.1. (*See p.* 286.)

CONCRETE MANUFACTURERS (NO. 1 LONDON), LTD., Brimsdown. T., Enfield 602; T.A., Darrobsco, Ave, London. (All descriptions of concrete products.) (*See pp.* 288–9.)

CONCRETE MANUFACTURING CO., No. 79 Arch, Queen's Circus, S.W. (General pre-cast concrete goods.)

CONCRETE SUPPLY & MARKETING CO., LTD., 66 Victoria St., S.W.1. T., Vic. 8960; T.A., Consupmar, Sowest, London. (Concrete marketing agency.) (*See p.* 287.)

COOK, W. L., & CO., LTD., 233 Clapham Rd., S.W.9. T., Brixton 826. (Partition slabs; blocks.)

C.R. BUILDING CONSTRUCTIONS, LTD., 296 Vauxhall Bridge Rd., S.W.1. T., Vic. 2574; T.A., Rapconstru, Churton, London. (Building units; fencing posts; paving flags; garden frames; door hoods.)

DARLINGTON FENCING CO., LTD., 5 Lloyd's Ave., E.C.3. T., Avenue 990; T.A., Wyrfensin, Phone, London. (Post and wire fencing, post and chain fencing, post and tube fencing, post and rail fencing to order only.)

EASTWOODS, LTD., 47 Belvedere Rd., S.E.1. T., Hop. 3448; T.A., Eastwood, Watloo, London. (Partition slabs; fixing bricks.)

ELGOOD, E. J., LTD., 428 Old Kent Rd., S.E.1. T., Hop. 4254. (Breeze partition slabs.)
EMPIRE STONE CO., LTD., 231 Strand, W.C.2. T., Gerrard 8152; T.A., Empirstone, London. (Paving slabs; fence posts.)
HUGHES & LANCASTER, LTD., 16 Victoria St., S.W.1. T., Vic. 4772; T.A., Voidance, London. ("Bonna" steel and reinforced concrete pipes, to order only.)
LONDON PHOSPHATE SYNDICATE, LTD., Sussexwharf, S.E. (Blocks and slabs.)
MANUFACTURED CONCRETE WORKS, LTD., 39 Victoria St., S.W.1. T., Vic. 5159; T.A., Ramified, Sowest, London. (Pipes; posts; blocks; kerbs; slabs.)
MEARS, JOSEPH, LTD., Crab Tree Wharf, Crab Tree Lane, S.W.6. T., Hammersmith 53. (Breeze partition slabs; building blocks; fixing bricks. Lintels, to order only.)
MURIBLOC (PARTITION SLABS), LTD., Prince's Wharf, Jews Row, S.W.18. T., Battersea 1312; T.A., Muribloc, Wandsworth. (Blocks; partition slabs; lintels.)
STUART'S GRANOLITHIC CO., LTD., 63 Lincoln's Inn Fields, W.C.2. T., Holborn 5268; T.A., Granolith, Holb, London. (Granolithic pavings; cast stonework; pavings; road blocks.)

MIDDLESEX.—

ADAMS (DENHAM), LTD., Denham Lodge, Uxbridge. T., 228. (Blocks; partition slabs; kerbs; posts.)
CONCRETE MANUFACTURERS (NO. 1 LONDON), LTD., Brimsdown. T., Enfield 602; T.A., Darrobsco, Ave, London. (All descriptions of concrete products.) (*See pp.* 288–9.)
FERRO-CONCRETE ROOF PLATE CO., Station Approach, Shepperton-on-Thames. T., Walton-on-Thames 337. (Partition slabs; fixing bricks; hollow blocks.)
KING, A. J., 2 Rutland Rd., Harrow. T.A., Silo, Harrow. (Silos, to order.)

NORFOLK.—

GIRLING & SMITH, Cromer. T., 93. (Posts, headstones, to order only.)
NORFOLK CONCRETE PRODUCTS CO., LTD., Stalham. T., Stalham 10; T.A., Concrete, Stalham. (Blocks; posts; tiles; partition slabs.)

NORTHAMPTONSHIRE.—

EXCELSIOR PATENT STONE CO., LTD., Finedon Sidings, Northamptonshire. T., Finedon 10; T.A., Excelsior, Finedon. (Paving flags; kerbs; tubes; cisterns; troughs; cowhouses; dressings and staircases.)

NORTHUMBERLAND.—

FERGUSON, W., & SON, Prudhoe St., Newcastle-on-Tyne. T., Central 1506. (Blocks; partition slabs; artificial stone.)

NOTTINGHAMSHIRE.—

BASFORD TILE AND STONE CO., Central Ave., Nottingham Rd., Nottingham. (Tiles; blocks; slabs.)
TRENT CONCRÉTE, LTD., Colwick, Nottingham. T., Carlton 62; T.A., Concrete, Netherfield. (Blocks; partition slabs; paving slabs; steps; lintels. Artificial stone, to order only.) (*See p.* 300.)
WORKSOP STONE CO., LTD., Claylands Works, Gateford Rd., Worksop. T., 243. (Artificial stone.)

Shropshire.—

Nicholas, E. H., Coleham, Shrewsbury. (Blocks; partition slabs.)

Somerset.—

Poole, H. J., & Son, North Town, Taunton. T.A., Concrete, Taunton. (Partition slabs; fixing bricks; floor blocks; lintels; posts; well tubes; sills; troughs; copings.)

Wharf Lane Concrete Co., Ltd., Ilminster. T., 36. (Fences; pipes; slabs; troughs and stall divisions; tanks. (*See p.* 301.))

Staffordshire.—

Ball & Robinson, Trent Bridge Works, Stoke-on-Trent. T., Hanley 941. (Blocks; lintels; fencing posts; paving slabs.)

Brammar and Patrick, Longfield Rd., Hartshill, Stoke-on-Trent. (Blocks, to order only.)

McLean, John, Coven, nr. Wolverhampton. (Partition slabs.)

Shire Oak Sand, Gravel & Concrete Works, Shire Oak, Stonnall, Walsall. T., 31; T.A., Concrete, Walsall Wood. (Fence posts; blocks; channel and paving slabs; partition slabs.)

Tarmac, Ltd., Ettingshall, Wolverhampton. T., Bilston 201; T.A., Roads, Wolverhampton. (Blocks; tiles; posts; kerb; cable covers; joint "coffins"; indicator posts.)

Vernon & Son, Lower Penn, Wolverhampton. T., 69. (Tiles; posts; lintels; blocks.)

Windmill Cement Co., Ltd., Mount Pleasant, Bilston. T., 85; T.A., Windmill, Bilston, 85. (Paving slabs; sills; kerbs; partition slabs; blocks; posts; garden edging; pillar caps; stop-tap blocks; heads.)

Surrey.—

Concrete Industries, Ltd., Broomleaf Works, Farnham. (General concrete building requisites.) (*See p.* 286.)

Coulsdon Partition Co., Lansdowne Rd., Croydon. T., 886. (Breeze partition slabs.)

Heffer, Bert, Mono Pipe Works, Lower Green Rd., Esher. T., 440; T.A., Mono, Esher. (Sewer pipes.)

Plasm Decoration Co., Manor Rd., East Molesey. T., Molesey 452. (Garden ornaments; balustradings.)

Redhill Tile Co., Ltd., Kingsfield, Redhill. T., Redhill 473. (Tiles; partition slabs; floor tiles; posts; heads and sills.) (*See pp.* 298–9.)

Sergeant, James W., Ltd., 147 London Rd., Kingston. T., Kingston 200. (Partition slabs.)

Triangular Construction Co., Ltd., Imber Court, East Molesey, Surrey. T., Esher 341; T.A., Triangular, East Molesey. (Partition slabs and blocks in clinker and concrete.)

Warwickshire.—

Elwell, John, Ltd., Phœnix Ironworks, Birmingham. T., Midland 1762; T.A., Sections, Birmingham. (Gate and fencing posts.)

Midland Slab & Adamant Co., Northumberland St., Vauxhall, Birmingham. (Blocks; fence and gate posts; paving slabs; lintels; partition slabs; fixing bricks; mouldings.)

Quinton Bros., Newbold-on-Stour, Stratford-on-Avon. (Blocks; partition slabs; well covers; bricks; lintels.)

Stiff's Concrete Co., Ltd., 5 Edmund St., Birmingham. T., Central 2896. (Slabs; kerbs; sills; steps.)

Trumper, C., & Sons, Alcester St., Birmingham. T., Midland 721. (Partition blocks.)

Wiltshire.—

Bradley, E. H., & Sons, The Mall, Swindon. (Blocks; posts; partition slabs.)

Yorkshire.—

Bolckow, Vaughan & Co., Ltd., Middlesbrough. T., 1101; T.A., Bolckows, Middlesbrough. (Flags; kerbs; heads; sills; steps; coping; hollow and solid blocks; breeze partition slabs; slag bricks.)

Bradford Concrete Block Co., Ltd., Empress Works, Legrams Lane, Bradford. T., 4700. (Blocks; partition slabs; heads; sills; steps.)

Concrete, Ltd., 7 Greek St., Leeds. T., 27508; T.A., Conlimcrete, Leeds. (Hollow floors; artificial stone dressings; staircases. To order only.)

Domus Building Co., Ltd., Providence Mills, Staincliffe, Dewsbury. (Blocks; heads; sills; cornices; copings.)

Foster Bros., Chassum St. Works, Manningham, Bradford. T., 5666. (Blocks; heads; sills; edging; partition slabs.)

Girlings' Ferro-Concrete Co., Ltd., Morley, nr. Leeds. T., 54; T.A., Girlings, Morley. (Blocks, balustrading, coping, sills, posts, fountains, slabs, mangers, sundials, tanks, troughs, vases, etc., from stock; direction posts, electric transmission standards, lamp standards, and telegraph poles, to order.)

Hensall Concretes, Ltd., 28 Eldon St., Barnsley. (Kerbs.)

Hull Concrete Stone Co., Ltd., Lorraine St., Stoneferry, Hull. T., Corpn. 1289. (Dressings for architectural work, to order only; partition slabs, from stock.)

Low Laithes Colliery Co., Ltd., Doric Kerb Works, Wakefield. T., Wakefield 275; T.A., Low Laithes Collieries, Wakefield. (Kerb and channel.)

Pickering, Walter, & Son, Garnett St., Bradford. T., 1395; T.A., 1395, Bradford. (Reinforced concrete roof gutters.)

Rochester & Ingham, Bolton, Bradford, Yorks. (Blocks.)

Thompson, J. H., Eastrington, nr. Hull. (Breeze blocks; partition slabs; heads and sills. To order only.)

Scotland.—

Bain & Brown, Ltd., 236 Leith Walk, Leith. T., 346. (Blocks, partition slabs, fence posts, from stock; sills, lintels, to order only.) (*See p.* 226.)

Bain, Wm., & Co., Ltd., Lochrin Works, Coatbridge. T., 230; T.A., Lochrin, Coatbridge. (Blocks; partition slabs; fencing posts; finishings.)

Bruce, Alex., & Co., 68 Gordon St., Glasgow. T., Central 6080; T.A., Sleepers, Glasgow. (Steel concrete sleepers.)

Calder Bros., 22 Elliot St., Arbroath. T., 42; T.A., Calder, Builders, Arbroath. (Blocks; sills; lintels; kerbing; channels; fence posts; partition slabs.)

Forrester, G., Farm Concrete Works, Baronald St., Rutherglen. T., 380. (Blocks; steps; jambs; lintels; mullions.)

Grandison, L., Altrive, Peebles. (Blocks; slabs; ridging.)

McNeil, W. N., Station Rd., Fairlie. T.A., Buildings, Fairlie. (Blocks; steps; sills.)

Patersons Concrete, Ltd., Kelvinside Station, Glasgow. T., Western 4092. (Blocks, to order only; partition slabs, from stock.)

Paton, J. K., 64 Prince's St., Perth. T., 44. (Blocks; partition slabs; bricks.)

Pollock, Alex. G., 134 Main St., Barrhead. T., 42. (Blocks, to order only.)

Price, Frank G., & Co., Limpet Works, Carmyle, nr. Glasgow. T., Shettleston 125; T.A., Price, Carmyle. (Blocks; partition slabs; lintels; sills.)

St. Fort Artificial Stone Co., St. Fort Station, Fifeshire. (Sills; lintels; steps; copings; kerb; channels; posts; blocks; fluted columns.)
Spence, J. D., Woodburn Concrete Block Works, St. Andrews. (Blocks.)
Waldie, E., 66 Union Row, Aberdeen. T., 718; T.A., Waldie, Aberdeen. (Blocks.)
Walls, A., 28 Thistle St., Stirling. T., 386; T.A., 386, Stirling. (General pre-cast goods.)
Wilkie, Wm., & Co., Ltd., 161 Millerfield Rd., Glasgow. T., Bridgeton 874; T.A., Fulfilling, Glasgow. (Hollow walls; partition slabs; cable joint boxes and troughs.)

Wales.—

Concrete Products, Corporation Rd., Newport, Mon. T., 2470; T.A., Hodson, Newport, 2470. (Breeze partition slabs; blocks.)
Craig-Lelo Quarry Co., Ltd., Gwyddelwern, nr. Corwen. T., 23; T.A., Lilo, Gwyddelwern. (Reinforced tubes; fence posts; paving blocks; flags; kerbs; masonry.) (*See p.* 290.)
Penarth Concrete Co., Ltd., Lower Penarth, Glamorgan. T., Penarth 5; T.A., Reinforced, Penarth. (Fence posts; sills; hoods; corbels; steps; slabs; blocks; heads; paving slabs; kerbing; channelling.)

Ireland.—

O'Hara, J. J., & Co., 29–31 Lincoln Place, Dublin. T., 2614; T.A., Tiling, Dublin. (Slabs; partition blocks; steps; plinths. To order only.)
Thompson, J. & R., Ltd., Roden St., Belfast. T., 804; T.A., Thompson, 804, Belfast. (Blocks; partition slabs; paving flags; cast concrete.)
Tullaghreine Concrete Utilities Factory, Tullaghreine, Carrigtwohill, Co. Cork. T.A., Concrete, Carrigtwohill. (Blocks; slabs; bricks; posts; hand-rails; balusters; roofing and flooring tiles; pier caps.)

PROOFERS AND HARDENERS.

Adamite Co., Ltd., Regent House, Regent St., W.C. T., Mayfair 224; T.A., Excellence, London. ("Colemanite" hardener.)
Brunner, Mond & Co., Ltd., Northwich. T., 1; T.A., Crescent, Northwich. (Silicate of soda; calcium chloride.) (*See pp.* 302–3.)
Building Products, Ltd., 44–46 King's Rd., S.W.3. T., Vic. 2590; T.A., Bylprodia, Sloane, London. ("Bareau" waterproofing powder; "Profit" waterproofing paste; "Ferrolithic" floor hardener; "Aqualithic" liquid dustproofer and hardener for existing floors.) (*See p.* 304.)
Buxton Lime Firms Co., Ltd., Royal Exchange, Buxton. T., 312; T.A., Buxton Lime, Buxton. (Hydrated lime.) (*See p.* 305.)
Castor Cement Waterproofing Co., 53 Victoria St., S.W.1. T., Vic. 1433; T.A., Don, London. ("Castor" waterproofer.)
Cement Industries, Siddals Rd., Derby. T.A., Cementin, Derby. (Chemicals and compounds.) (*See p.* 306.)
Ceresit Waterproofing Co., Docks, Gloucester.
Dreyfus, A., Ltd., Belper Works, Belper St., N.1. T., North 3730. ("Siccite" waterproofer.)

EARLE, G. & T., LTD., Wilmington, Hull. T., Central 4322; T.A., Cement, Hull. ("Medusa" waterproofing compound.) (*See p.* 210.)

FULLERSITE, 62 Baker St., S.W.1. T., Mayfair 5284; T.A., Fullersite, Baker, London. ("Fullersite" proofer.)

HEEANDI, LTD., 70 Victoria St., S.W.1. T., Vic. 1650; T.A., Heeandi, Sowest, London. ("Lapidolith" hardener; "Fermo" oilproofer.)

IRONITE CO., LTD., 11 Old Queen St., S.W.1. T., Vic. 5618; T.A., Thormotvin, Parl, London. ("Ironite" floor hardener.)

JONES, JNO., & CO., 12–13 Avenue Chbrs., Southampton Row, W.C.1. T., Museum 3219; T.A., Lastingly, London. ("Steel-crete" hardener, waterproofer, and oilproofer.)

KERNER-GREENWOOD & CO., LTD., St. Nicholas Quay, King's Lynn. T., 93; T.A., Greenwoods, King's Lynn. ("Pudlo.")

LILLINGTON, GEORGE, & CO., LTD., 69 High Holborn, W.C.1. T., Chancery 7437; T.A., Liquitalic, Westcent, London. (Metallic liquid floor hardener; oilproofer; acid-proofer; waterproofer; strengthener.)

MCNEILL, F., & CO., LTD., 14–24 Lamb's Passage, Bunhill Row, E.C.1. T., Clerkenwell 1643; T.A., Eyeball, London. ("Spartanite" waterproofer; "Flintesco" floor hardener; "Impervol" integral proofer.)

PETERS, C. A., LTD., Stores Rd., Derby. T., 399; T.A., Peters, Derby. (*See p.* 307.)

R.I.W. PROTECTIVE PRODUCTS CO., LTD. (*See* Toch Bros.)

SLATE INDUSTRIES, LTD., Coetmor Yard, Bethesda, N. Wales. T., Bethesda 4. ("Myrtox" filler.) (*See p.* 308.)

STAVELEY COAL & IRON CO., LTD., Chesterfield. T., 251; T.A., Staviron. ("Staveho" waterproofer.)

TOCH BROS., 74 Vicarage Lane, E.15. T., Maryland 1589; T.A., Cemenflor, Strat, London. ("Toxement" waterproofer; "R.I.W." acid proofer; plaster bond, bridge cement, "Flintox.") (*See pp.* 309–10.)

TORBAY & DART PAINT CO., LTD., 26–28 Billiter St., E.C.3. T., Ave. 1225; T.A., Torbay, Phone, London. ("Novoid" waterproofer; oilproofer; road and floor hardener.) (*See p.* 311.)

WATEREX CO., LTD., 104 High Holborn, W.C.1. T., Holb. 2075; T.A., Wotterex, London. ("Waterex" waterproofer; "Watco" floor preservative and binder.)

PROPAGANDA.

CONCRETE UTILITIES BUREAU, 35 Gt. St. Helens, E.C.3. T., Avenue 5422; T.A., Utilicon, Stock, London. (*See pp.* 281, 296, 312.)

REINFORCEMENT.

Barb Engineering Co., Saltney, Chester. T., 1098; T.A., Wonpees, Chester.

Birmingham Concrete Steel Co., 125 Edmund St., Birmingham. T., Central 3273. (*See p.* 228.)

Bradshaws' Reinforced Concrete Co., Ltd., 87 Windsor House, Victoria St., S.W.1. T., Vic. 8870. (*See pp.* 278–9.)

British Reinforced Concrete Engineering Co., Ltd., 1 Dickinson St., Manchester. T., City 8430; T.A., Brenforce, Manchester.

Brown & Tawse, Ltd., 3 London Wall Bldgs., E.C.2. T., London Wall 6240; T.A., Hexameter, Ave, London. (*See p.* 313.)

Darlington Fencing Co., Ltd., 5 Lloyd's Ave., E.C.3. T., Ave. 990; T.A., Wyrfensin, Phone, London.

Dorman, Long & Co., Ltd., 4 Central Bldgs., S.W.1. T., Vic. 9600; T.A., Pugilism, Parl, London.

Expanded Metal Co., Ltd., York Mansion, Petty France, S.W.1. T., Vic. 8809; T.A., Expamet, Sowest, London. (*See pp.* 314–5.)

Greening, A., & Sons, Ltd., 16 Finsbury St., E.C.2. T., Clerkenwell 1082; T.A., Setscrew, Finsquare, London.

Helical Bar & Engineering Co., Ltd., 72–74 Victoria St., S.W.1. T., Vic. 1940; T.A., Helistelba, Sowest, London. (*See p.* 316.)

Hill, Richard, & Co., Ltd., Middlesbrough, T., 106; T.A., Hills, Middlesbrough.

Indented Bar & Concrete Engineering Co., Ltd., Queen Anne's Chbrs., S.W.1. T., Vic. 1642; T.A., Patinbar, Parl, London.

Johnson's Reinforced Concrete Engineering Co., Ltd., 24 Lever St. Manchester. T., Central 1120; T.A., Buildings, Manchester.

Kirkstall Forge, Ltd., Leeds. T., Horsforth 164; T.A., Forge, Kirkstall.

Robinson, C. A., & Co., Anchor Iron Wharf, East Greenwich. T., Greenwich 94; T.A., Scrapetal, London.

Self-Sentering Expanded Metal Works, Ltd., 110 Cannon St., E.C.4 T., City 3201; T.A., Seltrussit, Cannon, London.

Trussed Concrete Steel Co., Ltd., 22 Cranley Gdns., S.W.7. T., Kensington 1049; T.A., Kahncrete, Fulroad, London.

United States Steel Products Co., 36–38 New Broad St., E.C.2. T., London Wall 8186; T.A., Steelmaker, London.

Walker-Weston Co., Ltd., 7 Wormwood St., E.C.2. T., London Wall 4434–5; T.A., Pyraminwal, Ave, London.

Weston-Reuter Co., Ltd., 2 Dean Farrar St., S.W.1. T., Vic. 6832; T.A., Eldeseado, Sowest, London.

Whitehead Iron & Steel Co., Ltd., Tredegar, Mon. T., 105; T.A., Whitehead, Tredegar.

Wire Tie Co., Siddals Rd., Derby. T.A., Wiringtie, Derby. (Wire ties and loops.) (*See p.* 317.)

ROAD CONTRACTORS (CONCRETE).

Acme Flooring & Paving Co. (1904), Ltd., Gainsboro' Rd., Victoria Park, E.9. T., East 5060; T.A., Dowelled, London.

Bain & Brown, Ltd., 236 Leith Walk, Leith. T., 346. (*See p.* 226.)

Baldry Yerburgh & Hutchinson, Ltd., 21 Queen Anne's Gate, S.W.1.

Boot, Henry, & Sons (London), Ltd., 12 Lower Grosvenor Place, S.W.1. T., Vic. 8325; T.A., Enribotsan, Sowest, London.

Bradshaw, Joseph H., Ltd., 4 St. Mary's Parsonage, Manchester. T., Central 4359; T.A., Bradphalte, Manchester.

Campbell, Kenyon & Co., Ltd., Victoria Rd., W.3. T., Chiswick; T.A., Campenyon, Act, London.

Campbell, W. J., & Son, Ravenhill Rd., Belfast. T., 491; T.A., Campbells, Contractors, Belfast.

Consolidated Construction Co., Ltd., 9 Cloak Lane, E.C.4. T., City 8176; T.A., Solconstru, Cannon, London.

Cronk, J., & Son, 33 Streatham Place, S.W.2. T., Streatham 224.

Farrow, Howard, 1 Russell Parade, N.W.11. T., Finchley 448.

French, W. & C., Buckhurst Hill, Essex. T., Woodford 557; T.A., French, Buckhurst Hill.

Gray's Ferro-Concrete Co., 156 St. Vincent St., Glasgow. T., Central 2558; T.A., Monolith, Glasgow.

Griffiths, William, & Co., Ltd., Hamilton House, Bishopsgate, E.C.2. T., Bishopsgate 1055 and Central 1721; T.A., Griffiths, Stone, Phone, London.

Hobson, A., & Sons, Higher King St., Hurst, Ashton-under-Lyne. T., 1073.

Holloway Bros. (London), Ltd., Bridge Wharf, Grosvenor Rd., S.W.1. T., Vic. 8560; T.A., Antefixa, Churton, London.

Ireland, Ernest, Lower Bristol Rd., Bath. T., 557; T.A., Ireland, Contractor, Bath.

Jackaman, A., & Son, Ltd., 22 Mackenzie St., Slough. T., 31; T.A., Jackaman, Slough. (*See p.* 234.)

Jackson, D. T., 106 Ripple Rd., Barking. T., East Ham 113; T.A., Jackson, Barking.

Jones, Walter, & Sons, 64 Victoria St., S.W.1. T., Vic. 6661.

KIRK & RANDALL, LTD., 146–7 Grosvenor Rd., S.W.1. T., Vic. 2945; T.A., Vicrandic, Churton, London. (*See p.* 235.)

MCALPINE, SIR ROBERT, & SONS, 50 Pall Mall, S.W.1. T., Gerrard 6754; T.A., Ferrocrete, Piccy, London.

MANDERS, W., & Co., 21–22 Temple Chambers, Temple Avenue, E.C.

MITCHELL, F., & SON, LTD., River Place, City Road, Manchester.

MORRISON & SONS, LTD., Wavertree, Liverpool. T., Wavertree 35.

MOWLEM, JOHN, & Co., LTD., 41 Ebury Bridge Rd., S.W.1. T., Vic. 3348; T.A., Mowlem, Sloane, London.

MUIRHEAD, W., MCDONALD, WILSON & Co., LTD., 41 Parliament St., S.W.1.

NOTT, BRODIE & Co., LTD., 60 Queen Sq., Bristol. T., 4182; T.A., Concrete, Bristol.

NUTTALL, EDMUND, SONS & Co., LTD., Trafford Park, Manchester. T., Trafford Park 310; T.A., Tunnelling, Manchester.

PARKINSON, J., & SONS (BLACKPOOL), LTD., 171 Shaftesbury Ave., W.C.2. T., Regent 4587.

PARTINGTON, JONATHAN, LTD., Wade St., Middleton Junction, Manchester. T., Middleton 20.

POLLARD, GEORGE, & Co., LTD., Taunton. T., 292.

PRESCOTT, SIR WILLIAM, & SONS, LTD., 422–3 Salisbury House, E.C.2. T., London Wall 7384; T.A., Prescotize, Ave, London.

ROADS & PUBLIC WORKS, LTD., 15 Dartmouth St., S.W.1. T., Vic. 971; T.A., Ruebilder, Parl, London.

SANGWIN, LTD., Stepney Lane, Hull. T., 7976.

SMETHURST, S. & J., LTD., Rochdale Rd., Oldham. T., 194; T.A., Buildhurst, Oldham.

SPEIGHT, L. J., Sardinia House, Kingsway, W.C. T., Holb. 1467; T.A., Steelcrete, Holb, London.

STEWART & MCDONNELL, 6–7 Cowley St., S.W.1.

STUARTS GRANOLITHIC CO., LTD., 63 Lincoln's Inn Fields, W.C.2. T., Holborn 5268; T.A., Granolith, Holb, London.

SUTHERLAND, JOHN, Abercynon, Glam. T.A., Sutherland, Abercynon.

THOMAS & EDGE, 79 New Rd., Woolwich, S.E. T., Woolwich 64; T.A., Tomazedgra, London.

TRENTHAM, G. PERCY, LTD., 150 Southampton Row, W.C.1. T., Museum 8370; T.A., Pertren, Westcent, London.

TROLLOPE & COLLS, LTD., 5 Coleman St., E.C.2. T., London Wall 4826; T.A., Trocoll, Phone, London.

VERDURA HARD COURT CO., Derwent Chambers, Derby. T.A., Verdura, Derby. (Paths and flat courts in colour.) (*See p.* 250.)

WATSON AND HORROCKS, LTD., 3 Victoria St., S.W.1. T., Vic. 770.

Wilson, Lovatt & Sons, Ltd., Clarence St., Wolverhampton. T., 1130; T.A., Lovatt, Wolverhampton.

Wilson, Thomas, 78 Broad St., Pendleton, Manchester. T., Pendleton 783; T.A., Wilson, Contractor, Pendleton.

Wimpey, G., & Co., The Grove, Hammersmith, W. T., Hammersmith 146.

Woodham, Henry, & Sons, Ltd., Sangley Rd., Catford, S.E.6. T., Lee Green 1067; T.A., Woodham, Catford.

Worthington, W. H., Ltd., 61 Rusholme Rd., Manchester. T., Central 2957 and 2958; T.A., Flagging, Manchester. (*See p.* 244.)

Yorkshire Hennebique Contracting Co., Ltd., Kirkstall Rd., Leeds. T., 20687. T.A., Ferro, Leeds.

ROAD ACCESSORIES.

Burn Brothers (London), Ltd., 3 Blackfriars Rd., S.E.1. T., Hop 5260. (Cesspools and grating; gulleys.) (*See p.* 318.)

PERIODICALS.

Architect, 6–11 Imperial Bldgs., Ludgate Circus, E.C.4. (Weekly), 6*d.*

Architects' Journal, 27–29 Tothill St., S.W.1. (Weekly), 6*d.*

Architectural Review, 27–29, Tothill St., S.W.1. (Monthly), 2*s.* 6*d.*

British Builder, 329 High Holborn, W.C.1. (Monthly), 1*s.*

British Engineers' Home and Export Journal, 32 Victoria St., S.W.1. (Monthly), 2*s.*

Builder, The, 4 Catherine St., W.C.2. (Weekly), 9*d.* (*See p.* 327.)

Builders' Merchants' Journal and Builders' Ironmonger, 155 Fenchurch St., E.C.3. (Monthly), 1*s.*

Building Industries, 134–138 Holm St., Glasgow. (Monthly), 6*d.*

Building News & Engineering Journal, Effingham House, Arundel St., W.C.2.

Concrete & Constructional Engineering, Editorial Office, 35 Great St. Helen's, E.C.3. Publishing Dept., 4 Catherine St., W.C.2. (Monthly), 1*s.* 6*d.*; annual subscription, 18*s.* post free. (*See pp.* 329–30.)

Contract Journal, 127–130 Tenple Chbrs., E.C.4. (Weekly), 9*d.*

Contractors' Record & Municipal Engineering, 27 Chancery Lane, W.C.2. (Twice weekly), 6*d.*

Ferro-Concrete, 24 Bride Lane, E.C.4. (Monthly), 6*d.*

Illustrated Carpenter and Builder, 8 Temple Ave., E.C.4. (Weekly), 2*d.*

Journal of the Incorporated Clerks of Works' Association of Great Britain, 50 Thurleigh Rd., S.W.12. (Monthly), 2*d.*

JOURNAL OF THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS, 92 Victoria St., S.W.1. (Fortnightly), 1*s.* 6*d.*

JOURNAL OF THE INSTITUTION OF STRUCTURAL ENGINEERS, Abbey House, Victoria St., S.W.1. (Monthly), 1*s.*

JOURNAL OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS (THE ARCHITECTURAL JOURNAL), 9 Conduit St., W.1. (20 Nos. per annum), 1*s.* 6*d.*

JOURNAL OF THE SURVEYORS' INSTITUTION, 12 Great George St., S.W.1. (Monthly), 2*s.* 6*d.*

MASTER BUILDER, 20–22 St. Bride St., E.C.4. (Weekly), 6*d.*

MUNICIPAL ENGINEERING, 8 Bream's Bldgs., E.C. (Weekly), 4*d.* (*See p.* 328.)

MUNICIPAL JOURNAL, Sardinia House, Kingsway, W.C.2. (Weekly), 3*d.* (*See p.* 331.)

NATIONAL BUILDER, Cromwell House, Surrey St., W.C.2. (Monthly).

PUBLIC WORKS, 24 Bride Lane, E.C.4. (Quarterly), 5*s.* per annum.

QUARRY AND SURVEYORS' AND CONTRACTORS' JOURNAL, 30–31, Furnival St., W.C. (Monthly), 8*d.*

ROADS AND ROAD CONSTRUCTION, 83–85 Farringdon St., E.C.4. (Monthly), 1*s.* (*See p.* 332.)

SPECIFICATION, 27–29 Tothill St., S.W.1. (Annual, January), 10*s.* 6*d.*

SURVEYOR AND MUNICIPAL AND COUNTY ENGINEER, 24 Bride Lane, E.C.4. (Weekly), 6*d.*

TOWN PLANNING REVIEW, 177 Brownlow Hill, Liverpool. (Quarterly.)

CATALOGUE SECTION

Please mention "The Concrete Year-Book" when communicating with Firms included in this Section.

IN the following pages are given further particulars of many of the businesses and products included in the Directory Section. From these extended announcements it will be possible to select just the machine or product required for any particular purpose, or to select a contractor in any district who has carried out work similar to that in contemplation.

The announcements are arranged alphabetically, according to the names of the firms, within the following sections :—

	PAGE
Aggregates and Sand	188
Asbestos-Cement Products	199
Books	320
Cement	201
Cement-making Sieves and Screens	200
Chemicals and Apparatus	219
Coloured Cements	220
Colouring Materials	222
Designers and Contractors for Reinforced Concrete	225
Flooring Contractors	245
Floor-Surfacing Materials	248
Floor-Levelling Machines	251
Machinery and Plant	252
Mould Oil	270
Paints for Cement	271
Periodicals	327
Photography and Process Engraving	319
Piling	272
Products	277
Proofers and Hardeners	302
Propaganda	312
Reinforcement	313
Road Accessories	318
Alphabetical Index	333

*** **Rates for space in the Catalogue Section may be obtained from "The Concrete Year-Book" (Concrete Publications, Ltd.), 35 Gt. St. Helen's, E.C.3.**

H. J. CHILD

20 LOWER PARK ROAD — PECKHAM, S.E.1

ALL KINDS OF SAND
AND AGGREGATES
FOR CONCRETE AND
REINFORCED CONCRETE

WASHED, CRUSHED AND
GRADED BALLAST
$\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in.

PIT BALLAST.

THAMES BALLAST.

WASHED PIT SAND.

RIVER SAND.

BREEZE.

RUBBISH CLEARED.

QUALITY AND SERVICE.

ALL MATERIALS OF
FIRST CLASS QUALITY.

LARGE OR SMALL
QUANTITIES SUPPLIED.

DELIVERY by 5-ton LORRIES
OR CARTS
TO SUIT REQUIREMENTS.

DELIVERY TO TIME
GUARANTEED.
Our Service is your Insurance against jobs being held up.

WRITE OR PHONE FOR
SAMPLES AND PRICES.

'Phone: New Cross 1317.

DEE-CLWYD GRANITE QUARRIES CO., LTD.
GWYDDELWERN near CORWEN NORTH WALES

STONE
Specially adaptable
for
making Concrete
free from cracks.

Quotations
on application.

—

Telegraphic Address
"Dee Clwyd
Gwyddelwern."

—

TARRED
MACADAM
which does not
wave
or
corrugate.

Telephone No.
Corwen 27.

DUNDEE SAND & LIGHTERAGE CO., LTD.

21 DOCK STREET DUNDEE

DREDGING CONTRACTORS
SAND AND GRAVEL
MERCHANTS.

CHAS. M. MURDOCH, *Manager.*

SAMPLES AND PRICES
ON APPLICATION.

Chief Office—21 Dock Street, Dundee.

Perth Office—27 Skinnergate.

Telegrams : "Emplomutua, Dundee."

Telephone : 2052 Dundee.

„ 242 Perth.

Stores—Earl Grey Docks, Dundee.

Sand and Gravel Pits—St. Fort.

Stores—Upper and Lower Harbour, Perth.

CONTRACTORS TO H.M.
ADMIRALTY, WAR OFFICE,
AND PUBLIC WORKS.

CLEAN WASHED
SAND AND GRAVEL
BY ROAD, RAIL OR SEA.

For over a quarter of a century we have successfully specialized in marketing the various grades of Sand and Gravel required for Industrial and other purposes.

Our Products are recognized by prominent Engineers, Architects, Reinforced Concrete Experts, and Tradesmen, as "standard," owing to their uniform high quality.

Our success in maintaining and guaranteeing the quality lies in the adoption of most ingeniously designed plant, in which are embodied quite a number of inventions, in addition to Patent No. 136624, "System of loading Vessels with Solids from Centrifugal Pumps." The plant enables us to efficiently dredge, wash perfectly clean, and grade, enormous quantities at extremely low cost, the product retained for market being rendered absolutely free from all Clay, Mud, Slime, Silt, or Rubbish.

This is better understood by the fact that on an average there is used over ten tons of water to wash, clean, and grade every ton of Sand or Gravel we retain for our Customers.

GLAREA, LIMITED

BUSH HOUSE ALDWYCH LONDON, W.C.2

SEND US

YOUR ENQUIRIES

FOR

BALLAST,

GRAVEL,

SHINGLE,

SAND.

TELEGRAMS:

"WORKBENCH,

PHONE, LONDON."

TELEPHONES:

CITY 9472.

„ 9473.

„ 9474.

THE HILLHOUSE QUARRY COMPANY

TROON SCOTLAND

THE PERFECT AGGREGATE FOR MASS OR REINFORCED CONCRETE IS HILLHOUSE CRUSHED AND GRADED STONE known locally as BLUE WHINSTONE.

The Geological Description of this Stone is ANALCITE OLIVINE DIABASE or TESCHENITE, and the formation is BASALTIC. It is HARD, TOUGH, NON-ABSORBENT, and CLEAN.

The daily output is about 600 tons, and it is screened into the following sizes :— $2\frac{1}{2}$ in., $2\frac{1}{4}$ in., 2 in., $1\frac{1}{2}$ in., $\frac{3}{4}$ in., $\frac{1}{2}$ in., $\frac{3}{8}$ in., $\frac{1}{8}$ in., SAND and SUPERDUST, the last named being collected by suction, or pulverized to pass 80 per cent. through a mesh of 32,000 holes per square inch. The smaller sizes are passed through Dryers and Mechanical Cleaners before being screened.

As the weather does not affect our output, and our Storage Bins have a capacity of 7,000 tons of finished stone, deliveries can be arranged to suit the purchaser, by RAIL, SEA or ROAD.

NORTH LONDON BALLAST & SAND CO., LTD.

48c GRAY'S INN ROAD LONDON, W.C.

MANUFACTURERS
of
WASHED and
REMIXED BALLAST to any specification.

WASHED BALLAST (no sand).

WASHED SAND.

WASHED and GRADED SHINGLE, $\frac{1}{8}$, $\frac{3}{8}$ and $\frac{3}{4}$ inch or to any other specification.

The above material is all washed and graded and gives the best results for any class of concrete, also for tardressing or blinding.

UNWASHED BALLAST and SAND, also HOGGIN, can be supplied. Cannot be surpassed for quality.

For all information apply to
JAMES DICKSON,
Receiver for the Debenture Holders of The North London Ballast & Sand Co., Ltd., 48c Gray's Inn Road, London, W.C.

Telegraphic address :
Dicksonia, Holb., London.

Telephone :
Holborn 4650.

———

Works : Angel Road Station, L. & N.E.Ry. Edmonton.

Telephone : Tottenham 88.

———

Write for Prices, Samples and Particulars.

C. A. PETERS, LTD.

STORES ROAD WORKS — DERBY

Telegrams : "Peters, Derby."
Telephone : Derby 399.

Offer to the Concrete trade all the types of aggregates necessary for fancy or special work as listed below.

Special prices will be arranged for regular wagon load deliveries.

All usual grades or sizes available.

White, Grey, Yellow, and Blue Spars.

Grey, Green, Buff, and Red Granites.

White, Buff, Red, and Blue Limestones.

Purple, Red, Yellow, etc., rounded Pebbles.

Lustrous White, Black, Red, etc., Grains.

Green and Black Basalts, etc.

"Everwear" natural and artificial abrasive Grains.

White, Yellow, Buff, Red, Black, Green, etc., Marble for Terazzo Flooring, etc.

Green, White, Red, Blue, Yellow, Black, etc., Pottery Grains.

Granulated Glass, all colours.

Mother-of-pearl chips, pieces, etc.

Ground Mica in all necessary grades.

Black-red Glance (a lustrous glimmering powder).

Coloured Sands, etc., of many varieties.

Imitation Granite mixtures, etc.

THE SANDHILLS COMPANY

101 LEITH WALK — LEITH

ESTABLISHED 1901.

WE desire to bring before the notice of Surveyors, Architects, Contractors, and the building trades generally, the fact that we have at our disposal unlimited supplies of sand and gravel.

We control and own extensive sand deposits at Hawthornden, Musselburgh, Portobello (Midlothian), Bathgate (Linlithgowshire), and Pettycur (Fife). These, together with efficient equipment, and labour skilled in the selection of material suited for different requirements, enable us to supply any contract, large or small, entrusted to us.

Amongst the many contracts, for which we have supplied material, may be mentioned the following :—

The Rosyth Naval Base (hundreds of tons daily for six years);

Edinburgh Corporation Housing Schemes;

The New Prison, Saughton;

The Craigentinny Sewer;

The Electric Power Station, Portobello;

and

The Lothian Railway.

We invite enquiry, and will gladly forward samples on request.

'Phone : Leith 272.

Telegrams : "Sandhills, Leith."

SNETTISHAM SHINGLE CO., LTD.

SNETTISHAM KING'S LYNN NORFOLK

Supply all Grades of Clean Shingle and sharp clean Sand free from all deleterious matters; requires no washing.

USES.

(1) For roads after tar spraying.

(2) Concreting and building purposes.

(3) Manufacture of glass.

(4) Garden paths (prevents weeds).

And for various other purposes.

SIZES.—As dug containing about 35 per cent. sand.

2 in. to $\frac{3}{4}$ in. clean
$\frac{3}{4}$ in. to $\frac{5}{8}$ in. ,,
$\frac{5}{8}$ in. to $\frac{1}{2}$ in. ,,
$\frac{1}{2}$ in. to $\frac{3}{8}$ in. ,,
$\frac{3}{8}$ in. to $\frac{1}{4}$ in. ,,
$\frac{1}{4}$ in. to $\frac{1}{8}$ in. ,,

and clean sharp graded sand.

This material can be supplied crushed or not crushed, also free of sand as required, or a mixture containing any percentage of crushed stone.

Can be railed up to 200 tons per day.

Barges up to 150 tons can load at beach at rate of 25 tons per hour.

NO DELAY. ORDERS PROMPTLY EXECUTED.

Terms: Net Cash Monthly.
Write for Quotations.

INDEPENDENT INVESTIGATIONS show that:—

"*SALINE TEST.*—The percentage of salt found in the *Foreshore Shingle* was 0.161 per cent. This quantity may be considered in no way detrimental to the aggregate from the view of the finished concrete. There was only a very slight trace of salt in the *background shingle.*"

"*CONCRETE TEST.*—2$\frac{3}{4}$ in. Cubes were made of the shingle and the figures given are the crushing strength in lbs. per sq. in.

	Lbs. per sq. in.
7 days. ..	3,650
28 days. ..	5,550

"The Shingle can be used *without washing* for the finest class of concrete work."

THE STANCLIFFE ESTATES CO., LTD.

DARLEY DALE DERBYSHIRE

'*Phone*: No. 29 Matlock.

'*Grams*: Stancliffe,
Two Dales.

PROPRIETORS
OF THE
FAMOUS ORIGINAL
DARLEY DALE
STONE QUARRIES.

Broken stone for concrete aggregate a speciality.

Approximate weight, 20 cwts. per cube yard.

Can be supplied screened in the following sizes :—

To pass 2 in., $1\frac{1}{2}$ in., $\frac{3}{4}$ in. and $\frac{1}{4}$ in. ring.

A hard gritstone breaking up into nice angular pieces which form a splendid key, and to which the cement readily adheres. It is a most suitable aggregate for concrete work of all descriptions.

Quotations and further particulars will be gladly supplied on application.

J. H. WALKER & CO.

LAYERTHORPE BRIDGE YORK

Clean, Sharp,
River Ouse Sand.

—

Pit Sand.

—

Washed Gravel Sand,
through $\frac{1}{4}''$ screen.

—

Unscreened Pit Gravel
for
Concreting,
Carriage Drives,
and
Footpaths.

Washed and
Screened Gravel,
$\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, $1''$, $1\frac{1}{2}''$.

—

Crushed and
Screened Stone,
$\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{3}{4}''$.

—

All enquiries to

LAYERTHORPE BRIDGE,
YORK.

Telephone No. 251.

ETERNIT PIETRA ARTIFICIALE (LONDON), LTD.

NORFOLK HOUSE LAWRENCE POUNTNEY HILL LONDON, E.C.4

THE LARGEST PRODUCERS OF ASBESTOS-CEMENT GOODS IN EUROPE.

CAPACITY 80,000 TONS PER ANNUM.

Owing to our system of mass production our working costs are reduced to a minimum, and we are therefore in a position to sell at competitive prices with Galvanized Iron roofing in all parts of the world.

THERE ARE 100 BRANCHES AND DISTRIBUTING AGENCIES FOR "ITALIT" IN THE EXPORT MARKETS OF THE WORLD.

"ITALIT" is produced in the form of:—

CORRUGATED SHEETS,
FLAT SHEETS,
DIAGONAL TILES, AND
ETRUSCAN SLATES.

Write for illustrated booklet fully describing the properties and applications of "ITALIT."

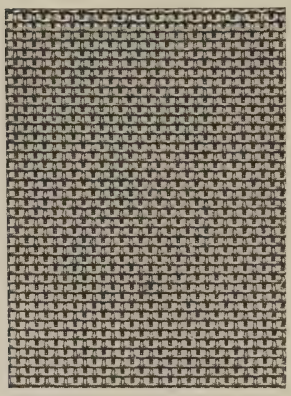
Normal centering of purlins 2ft. 9in. SAFE LOAD 5 Cwts. concentrated.

"ITALIT" is produced in specially designed machines, with asbestos uniformly distributed, combined and interlaced with the cement so as to constitute a tough and woven fabric. The layers adhere so firmly to each other that, after reaching the mature stage, "ITALIT" is found on fracture to be void of all stratification or lamination. The Asbestos not only gives the product increased incombustibility, resiliency and durability in varying conditions of climate, but also the outstanding characteristic of affording resistance to shock, vibration, transverse and tensile stresses, which further increases in ratio with its age.

Telephone: City 8886.
Telegrams: "Italitiles, Cannon, London."

F. W. POTTER & CO.

PHIPP STREET LONDON, E.C.2



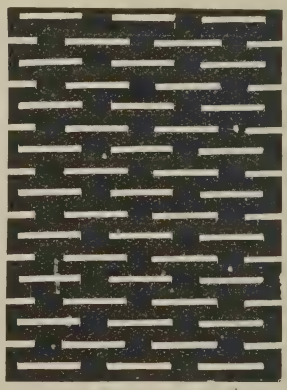
WIRE WEAVERS
WIRE WORKERS

Woven Wire :
- In all Metals
- In all Meshes
- In all Strengths

Sieves and Screens :
- Testing Sieves
- Gravel Sieves
- Locket Screens
- Rotary Screens

Heavy Steel Screening

Fine Wire Cloth



IRONWORKERS
ENGINEERS

Perforated Metals
Sheet Metal Work
Wrought Iron Work
Gear Cutting
Ventilating Fans
General Engineering

Catalogues Free on Application.

Telegraphic Address :
" Wirework, Finsquare, London."

Telephone Nos. :
Bishopsgate 2177 & 2178.

THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS, LTD.

PORTLAND HOUSE, LLOYD'S AVENUE, E.C.3

"CONCRETE FOR PERMANENCE"

Sole manufacturers of the undermentioned brands of BRITISH PORTLAND CEMENT.

"Hand"
"Anchor"
"J. B. White & Bros."
"Pyramid"
"Ferrocrete"
"Nine Elms"
"Lighthouse"
"Hilton"
etc.

These brands have a reputation of upwards of a century, and are renowned the world over for possessing those qualities that are most desirable in Portland Cement, viz., Great Strength, Uniformity and Soundness.

Telegrams :
"Assoporcem, London."

Telephone :
Avenue 5690.

APCM

THE BRITISH PORTLAND CEMENT MANUFACTURERS, LIMITED

4. LLOYD'S AVENUE LONDON, E.C.3

The Brands of
BRITISH PORTLAND CEMENT
manufactured by the British Portland Cement Manufacturers, Limited, are made in accordance with the requirements of the British Standard Specification, and will be found not only to comply with every test called for by that Specification, but the tensile strains are far in excess of its requirements.

Use

BPCM

BRANDS OF BRITISH PORTLAND CEMENT.

Some of the
GREAT CONTRACTS
which have been carried out with B.P.C.M. cement:—

Simonstown Dockyard Extensions,
Keyham Dockyard Extensions,
Singapore Harbour,
Peterhead Harbour,
Valparaiso Port Works,
Buenos Ayres & Pacific Railway,
South African Railways,
Egyptian State Railway,
Gold Coast Railway,
Tower Bridge, London.

Telegrams :
" Britporcem, London."
Telephone :
Avenue 6404.

BRITISH STANDARD CEMENT CO.

110 FENCHURCH STREET LONDON, E.C.3

Sole Proprietors

E. J. & W. Goldsmith, Ltd.

Manufacturers of

PORTLAND CEMENT

of the

HIGHEST QUALITY

—

Deliveries by

ROAD, RAIL, or WATER.

Telegrams :

"Tricolor, Fen, London."

Telephones :

Avenue 192, 196 & 197.

Contractors to :

WAR OFFICE,

ADMIRALTY,

INDIA OFFICE,

LONDON COUNTY COUNCIL.

—

THOUSANDS

OF TONS

SUPPLIED TO

BRITISH EMPIRE

EXHIBITION,

KIRKCALDY

AND

LOWESTOFT

SEA DEFENCE

WORK, ETC., ETC.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

A NEW CEMENT (1)

All present and prospective artists in Concrete, Plaster, Carton-Pierre, Papier-Mâché, Terra-Cotta, Clay, Metals, Plastics, etc., are requested to write us for particulars of our new special Artistic Casting Cements and mixtures.

Available in all grains, grades and colours, which are best poured in an almost liquid state, and which speedily set rock hard in simple or intricate moulds of sand, wax, plaster, wood, gelatine, glass, or other materials.

—

Models and designs developed.

—

Moulds made for sale, exchange or hire.

—

Technical advice given on raw materials, methods, etc.

—

In writing state fully your requirements.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

A NEW CEMENT (2)

Concrete workers on the lookout for a real novelty in Concrete Products, for which exclusive district agreements will be entered into, should write us for samples and particulars of our new Polishable Cements for highly glazed Artificial Marble manufacture.

—

Samples of the product will be sent on request.

—

Methods will be taught you free.

—

We will help you find markets and develop trade inside your territory.

We will provide the materials, etc., necessary to begin.

—

Small capital is needed.

—

First outfit costs about £100, including a good supply of Cement. The material can be cured in two days or less and ready to market, costing only about 2*s.* per sq. yd. for 1 in. slabs.

—

As far as we are aware this is the first cement offered that will satisfactorily reproduce polished hard permanent Artificial Marble, Serpentine, Granite, etc., in all colours, and without friction, wax, paint, polish or other coating. Suitable for inside or outside use.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

A NEW CEMENT (3)

We offer to Flooring Contractors, and many other users of Cement who appreciate very great strength, and speedy hardening, our *Special Flooring Cements*, which have many exceptional and valuable qualities, including :—

Slow Setting, giving ample time to work and lay.

Low in price, only about 20*s.* per ton above ordinary cement.

Available in Grey and all other colours at proportionate extra cost.

Fast hardening, giving a wonderfully high test at two days with 3 : 1 sand.

Increases regularly in strength and hardness for years.

Is a true Portland Cement, chemically and physically.

May be laid over common Cement foundations or blended in any proportion with commoner Cements to improve them.

Permits early and better finishing of Terazzo and Mosaic work.

Is the strongest, hardest, and densest Portland Cement on the Market.

Makes the best possible Concrete for paths, roads, floors, reinforced work, etc.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

A NEW CEMENT (4)

Especially developed for use by Hard Tennis Court Contractors, etc., who require large areas finished in an absolutely guaranteed permanent Green Colour with Cement that will wear exceptionally well, carry a heavy proportion of sand, cure quickly, and be more immune to weather changes while setting or afterwards than any regular Portland Cement.

To all users of this cement for Tennis Courts, Open-Air Skating Rinks, etc., we also offer our advisory services free, sending them detailed plans and instructions for getting the very best possible results.

We will provide, when our customers desire it, ample supplies of model cement Tennis Courts as Paper Weights, and other propaganda (without our name) to help them secure orders, as well as larger Exhibition models and other selling helps.

Where necessary we can arrange for suitable sand for mixing this top material to produce the porous Court so much desired by Clubs, Hotels, Municipalities, etc., or we can supply the whole top material already thoroughly machine-mixed after the Cement and pigment has been first ground together.

Any shade of green can be made to order, although we have standard varieties always in stock.

Every possible help will be afforded to Contractors taking up this line actively, and if desired enquiries for Courts laid in your district will be passed on to you, provided your standards of workmanship and price commend themselves to us.

A Green Cement that will absolutely stay green is a great achievement, especially when it is sold at the reasonable price we offer this product at, which incidentally is the only Green Cement we know of specially manufactured for Tennis Court work.

A Special Hard White Cement Mixture for inlaid lines is also available.

Send for particulars, etc.

THE CEMENT MARKETING COMPANY, LIMITED

8, LLOYD'S AVENUE — LONDON, E.C.3

The Cement Marketing Company, Limited, is the selling organization of :—

The Associated Portland Cement Manufacturers, Ltd.

The British Portland Cement Manufacturers, Ltd.

Martin, Earle & Co., Ltd.
and
The Wouldham Cement Co., Ltd.

whose well-known brands of

BRITISH
PORTLAND
CEMENT

have a world-wide reputation for excellence of quality.

The wide geographical area covered by the works and depots from which its deliveries are made, gives The Cement Marketing Company, Ltd., *unique facilities for prompt and regular despatch of Portland cement to any part of the United Kingdom and abroad.*

Telegrams :
"Portland, Fen. London."

Telephone :
Avenue 5690.

CEMENT MARKETING COMPANY, LIMITED.
8, LLOYD'S AVENUE LONDON, E.C.3

SERVICE.

The Cement Marketing Company Limited is anxious to give customers the benefit of its very extensive experience in the use of Portland Cement, and is always pleased to test and to give advice, free of charge, on aggregates which it is proposed to use for making concrete.

Enquiries are invited and should be addressed to the Company at the Head Office:

8, LLOYD'S AVENUE,
LONDON, E.C.3.

The following pamphlets will be forwarded, free of charge, on application:

PORTLAND CEMENT MEMORANDA.

HINTS ON CONCRETE PRACTICE.

PIPE JOINTING.

LIME FOR THE LAND —Its uses in Agriculture and Horticulture.

HOW TO USE KEENE'S AND PARIAN CEMENTS.

FILLERS FOR ASPHALTES.

C. & T. EARLE, LTD.

WILMINGTON HULL

BY APPOINTMENT TO

H.M. KING GEORGE V

BY APPOINTMENT TO

THE LATE KING EDWARD VII.

Lead Sealed

BRAND of
EARLE'S CEMENT.

Established 1809.

"MEDUSA"
WATERPROOFING
COMPOUND.

MANUFACTURED
BY
G. & T. EARLE, LTD.
WILMINGTON,
HULL.

Telephone :
National 4322 (five lines)
and
Corporation 807.

Telegrams :
"Cement, Hull."

GREAVES, BULL, & LAKIN, LTD.

HARBURY — LEAMINGTON

GREAVES'

PORTLAND

CEMENT.

Established 1840.

OUTPUT 1,700 TONS

WEEKLY.

Telegrams:

"Greaves, Harbury."

Telephone :

Southam 7.

Supplies to British Standard or any recognised Ferro Concrete specification under guarantee.

MARTIN, EARLE & COMPANY, LIMITED

8, LLOYD'S AVENUE — LONDON, E.C.3

" RHINOCEROS " Brand BRITISH PORTLAND CEMENT.

The Works of Martin, Earle & Company, Ltd., which are situated at Wickham, Rochester, on the river Medway, have recently been remodelled and equipped with the very latest type of cement making machinery.

The works have their own private railway sidings and over half of a mile of wharf frontage, and are exceptionally well placed for supplying Cement to all parts of the world.

The quality of Portland cement manufactured is of the very highest, and has been used on some of the most important contracts throughout the world during the last twenty-five years.

Telegrams :
" Vavasour, London."

Telephone :
Avenue 5420.

" RHINOCEROS "

BRAND.

CHARLES NELSON & COMPANY, LTD.

STOCKTON NEAR RUGBY

NELSON'S

CELEBRATED

"COCK" BRAND

PORTLAND

CEMENT.

Made from the Rocks and Shale of the Lower Lias Formation.

BLUE LIAS LIME

Extensively used in the London Tube Railways and Thames Tunnels, and

PATENT SELENITIC CEMENT.

Works and Head Office:
STOCKTON
(Near Rugby),
WARWICKSHIRE.

Telegrams:
Nelson, Stockton, Warwickshire.
Telephone: Southam 5.

BRANCHES:

LONDON:
16, South Wharf, Paddington, W.
Telegrams:
Nelson, South Wharf, Paddington.
Telephone: No. 135 Paddington.

MANCHESTER:
2 Mount Street.
Telegrams: Nelson, 2, Mount Street.
Telephone: 4420.

BIRMINGHAM:
Cambrian Wharf Crescent.
Telegrams: Nelson, Crescent Wharf.
Telephone: 1492 Central.

SHIP CANAL PORTLAND CEMENT MANUFACTURERS, LTD.

ELLESMERE PORT — CHESHIRE

Telephone : 53 Ellesmere Port (4 lines).

Telegrams : "Cement," Ellesmere Port.

"ENGLAND" BRAND PORTLAND CEMENT

OUTPUT AND DELIVERY.

Due to the recent modern improvements and extensions, ours is the largest independent cement factory in the United Kingdom, having an output of 5,000 tons "ENGLAND" Brand Portland Cement weekly, and prompt delivery of any quantity can be given.

FACILITIES.

Our Works have frontages on the Manchester Ship Canal, the Shropshire Union Inland Canal, and direct communications with the two main Railway Systems serving the North-west of England. From our Works Wharf on the Manchester Ship Canal we have recently loaded the largest individual Cement consignment ever shipped from the United Kindgom, viz. 7,700 tons "ENGLAND" Brand Portland Cement per the s.s. *Mongolian Prince* to Los Angeles.

QUALITY.

As an instance of the economy which can be effected by taking advantage of the superior quality of "ENGLAND" Brand Portland Cement, some years ago the Isle of Man Harbour Commissioners used our cement for the construction of a new breakwater in the proportion of 14 aggregate to 1 cement, and quite recently their Engineer reported that the work was standing well and had never given them a moment's anxiety since it was finished.

SHIP CANAL PORTLAND CEMENT MANUFACTURERS, LTD.

ELLESMERE PORT — CHESHIRE

UNIFORMITY.

We supply large regular quantities of "ENGLAND" Brand Portland Cement for special work requiring absolutely uniform high-grade Cement. For instance, the following are regular users :—

Messrs. Turner Bros., Rochdale (Asbestos Sheets).

Messrs. Tarmac, Ltd., Wolverhampton (Concrete Kerbs, Channels, etc.)

Messrs. Stanton Ironworks (Concrete Pipes).

TESTS.

The SUPER QUALITY of "ENGLAND" Brand Portland Cement is evidenced by the compressive strengths shown in the following tests :—

Concrete taken from bulk batch made with "ENGLAND" Brand Slow setting Cement, and immersed in a Liverpool Dock by the Mersey Docks & Harbour Board *for 9 years* :—

Compressive strength . . . 118 tons per sq. ft.
Proportions . . . . . 8–1 (9 inch cube)

Do. do. made with "ENGLAND" Brand medium setting Cement :
Compressive strength . . . 98.5 lbs. per sq. ft.
Proportions . . . . . 8–1 (9 inch cube)

Independent compression tests made on "ENGLAND" Brand Portland Cement used at Bellamy's Wharf, London:—

Mix.	Crushing strength in lbs. per sq. inch. Age 28 days.	Age 90 days.
4 : 2 : 1	5,520 . .	7,420
4 : 1½ : 1	6,420 . .	7,480

23 separate tests on shipment of 7,700 tons "ENGLAND" Brand Portland Cement to Los Angeles show the following average compressive strengths :

7 days (3.1) lbs. per sq. inch 3,223
28 days (3.1) lbs. per sq. inch 4,687

BRANCHES.

LONDON :
Woburn Lodge.
Upper Woburn Place, W.C.1.
Telephone : 4152 Museum (4 lines).
Telegrams : "Cementopor," 'Phone.
Billiter Square Buildings, E.C.3
Telephone : 3272 Avenue.
Telegrams : "Chiotos," Fen. London.

LIVERPOOL :
Drury Buildings.
Water Street.
And at
Tower Buildings.
Water Street.
Telephone : 1412 Bank (4 lines).
Telegrams : "Adherence."

THE SOUTH WALES PORTLAND CEMENT AND LIME CO., LTD.

PENARTH — GLAMORGAN

Established 1888. — *Capacity* 3,000 *tons Weekly.*

MANUFACTURERS OF
"DRAGON" BRAND
BEST PORTLAND CEMENT.

Our Cement is guaranteed to comply readily with all the requirements of the BRITISH STANDARD SPECIFICATION of August, 1920.

It is remarkably quick hardening and is pre-eminently suitable for REINFORCED CONCRETE WORK of every description.

Being specially well ground it has an unusually large percentage of flour and is very economical in use.

A few works on which DRAGON BRAND PORTLAND CEMENT has been used:

CONCRETE ROADS—

Hales Hall Estate, Shropshire; Lower Bristol Road, Bath; Station Road, Haverfordwest, etc., etc.

BRIDGES—

Glamorgan and Carmarthen Joint Counties Bridge, Loughor; Treffgarn Bridge, Pembroke; New Bridge at Taunton.

PUBLIC AND OTHER WORKS—

Grain Silos, Avonmouth.
Rank's Flour Mills, Barry.
Town Hall and Law Courts, Cardiff.
Queen Alexandra Dock, Cardiff.
Cardiff Waterworks, Llwyn-On and Rhiwbina.
Birmingham Waterworks.
Rhayader to Penybont, Northfield and Hagley Road.
Cardiff Western Sewerage.
Abertillery Water Board.
Taf Fechan Water Board.
Etc. etc.

SUPER CEMENT LTD.

10, UPPER WOBURN PLACE LONDON, W.C.1

Telephone : Museum 2490.
Telegrams : Cemsoopa, Kincross, London.

The use of SUPER CEMENT in the production of concrete does not necessitate any change from the methods employed in making concrete with Portland Cement. SUPER CEMENT takes the place of Portland Cement in the mix. The resulting concrete is denser, stronger, and more durable than Portland Cement concrete, and is, moreover, inherently waterproof. This quality is now generally recognised as a prime essential to permanent concrete construction wherever there is exposure to conditions involving continuous or intermittent contact with moisture.

SUPER CEMENT concrete is therefore particularly desirable not only where a water-tight structure is required, but also in all cases where permanence is sought under exposure to wear, weather, water, and other conditions which ordinarily restrict the life of concrete.

SUPER CEMENT is manufactured by :—

The Ship Canal Portland Cement Manufacturers Ltd, Ellesmere Port, Cheshire, The Tunnel Portland Cement Company, Ltd., Grays, Essex, and The Cam Cement Company, Ltd., Meldreth, Cambs.

Delivered to all parts by rail, road, or water, and is stocked by the leading Merchants.

There is only one brand of SUPER CEMENT, and it can be identified by a label on each sack, bearing Trade Mark.

Specify :—SUPER CEMENT SUBMARINE BRAND.

Used by :—Admiralty, War Office, Royal Air Force, Office of Works, Home Office, Post Office Engineers, Ministry of Agriculture, and Fisheries, Dominion Government of Canada, Provincial Governments of Ontario and Quebec, Canadian Pacific Railway, etc., etc.

COSTS

SUPER CEMENT is sold on following basis :—

In 4 ton lots d/d to Site at 30*s.* per ton above local price of Portland Cement.

In 2 ton lots d/d to Site at 35*s.* per ton above local price of Portland Cement.

In 1 ton lots d/d to Site at 40*s.* per ton above local price of Portland Cement.

COSTS OVER AND ABOVE PORTLAND CEMENT IN ACTUAL PRACTICE ARE AS FOLLOWS :—

Renderings 1″ thick

Mix 1 : 2—5½*d.* per yd super.
Mix 1 : 3—3¾*d.* per yd super.

Concrete

Mix 1 : 2 : 4—7*s.* 4*d.* per yard cube, or 10*d.* per yard super 4″ thick.

Slurry for Weatherproofing.

The entire cost of materials for SUPER CEMENT slurry is ¾*d.* per yard square, per coat.

The above are estimated on truck and lorry load prices.

SUPER CEMENT has proved itself the most efficient and economical medium, and where used in place of Asphalt in basements below water-level, needs no concrete or brickwork on top to resist water pressure.

Enquiries welcomed. Consultations free.

THE WOULDHAM CEMENT COMPANY, LIMITED

8, LLOYD'S AVENUE — LONDON, E.C.3

Established 1855.

Large quantities of the

WOULDHAM CEMENT COMPANY'S

brands of Portland Cement have been used on some of the most important engineering undertakings during the last 50 years, including :—

National Harbour, Dover, over 225,000 tons.
Port of Vera Cruz, Mexico, over 200,000 tons.
National Dry Docks, Malta, over 228,000 tons.
Abbassia Barracks, Cairo, over 15,000 tons.
Waterloo Station, London, over 14,000 tons.
P.L.A. New Offices, London, over 5,000 tons.
Valparaiso Port Works, Chili, over 45,000 tons.

The Wouldham Cement Company, Limited, whose well-known brands of Portland cement have a world-wide reputation, has one of the largest and most up-to-date works in the British Isles.

Only one quality of Portland cement is manufactured

THE BEST

Telegrams :
" Enriching, London."

Telephone :
Avenue 5420.

JAMES WOOLLEY, SONS & CO., LTD.

76, DEANSGATE MANCHESTER

(*Opposite Barton Arcade*)

Telephone :
City 7942

Telegrams :
"Pharmacy, Manchester."

Offices and Warehouse :
Victoria Bridge.

Laboratories and Works :
University Street.

LABORATORY FURNISHERS

BALANCES AND WEIGHTS.
Apparatus for Gas Analysis, Fat Extractions, Milk Analysis, Oil Testing, etc. Pure Chemicals and Standard Solutions.

MICROSCOPES AND ACCESSORIES.

Dissection Instruments, etc.

WOOLLEY **FIRST-AID** WOOLLEY

The
"VICTORIA"
CABINETS

The outcome of many years of specialization in First-Aid, are fitted to comply with the HOME OFFICE Requirements, and are so arranged that the contents are accessible at a moment's notice.

The
"VICTORIA"
DRESSINGS

Have the official approval of the Factory First-Aid Association, and bear the registered trade mark "FACTAID." They are put up in specially-prepared germproof cartons which ensure a sterile condition.

Under the Workmen's Compensation Act, 1923, every Factory must provide a First Aid Outfit.

Write for BOOKLET, Free on Request.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

NEW CEMENT
MIXTURES.

—

FOR FINISHING
WALLS, ETC.,
TO LOOK LIKE
ROUGH GRANITES,
WE MARKET A
NUMBER OF
MIXTURES, IN
VARIOUS TYPES OF
GRAIN AND COLOUR,
WHICH WHEN
CORRECTLY APPLIED
APPEAR IN TEXTURE
AND SPARKLE
VERY LIKE
REAL GRANITES.

THESE MIXTURES
ARE APPLIED
OVER A FRESH
SCRATCH COAT
OF
ORDINARY CEMENT
MORTAR,
AND
ON MANY
TYPES OF BUILDINGS
THEY MAKE A
VERY EFFECTIVE
AND
PERMANENT
DECORATIVE
FINISH.

C. A. PETERS, LTD.

STORES ROAD WORKS DERBY

Our line of
"PETEROID"
(registered)
Special Cements includes :

(1) WATERPROOF COLOURED CEMENTS for Stucco, Façade, etc., work in Black, White, Red, Cream, Green, etc.

(2) SPECIAL COLOURED FLOORING CEMENT, extra hard—in many colours.

(3) COLOURED CEMENTS FOR CONCRETE works—any shade to order—for tiles, blocks and all Concrete products ; exceedingly high in colouring qualities and in strength of Cement, but quite low in price.

(4) OUR "SPECIAL" BRAND OF GREY PORTLAND CEMENT, which has exceptional quick hardening qualities, and shows the greatest tensile and crushing strength of any true Portland Cement at 2 to 28 days or at 1 to 5 years—having continuous growth in strength and resistance. Is also very reasonable in price.

(5) WATERPROOFED GREY TANK CEMENT, and other special Cements made specially to order.

Telegrams :
"Peters, Derby."
Telephone : Derby 399.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

FOR DRY COLOURS OF ALL SHADES SUITABLE FOR TERAZZO, MOSAIC, COMPOSITION AND JOINTLESS FLOORS, TILES, CONCRETE PRODUCTS, ASBESTOS-CEMENT SHEETS, ETC.

ASK US FOR SAMPLES AND PRICES,

stating colour desired (enclosing sample to match if possible), saying what purpose they are required for, and the quantity desired.

COMPETITIVE PRICES, PERMANENCE AND HIGH STAINING POWER

are associated with our Cement, etc., pigments.

C. A. PETERS, LTD.

STORES ROAD WORKS — DERBY

Offer the most complete and reliable line of PERMANENT CEMENT COLOURS in the industry, identical with the pigments used in their various types of coloured Cements.

To the export trade and to large Home Consumers of oxide colours we offer them at the right prices, in qualities which are chemically and mechanically specially prepared for Cement work, and in all shades. (Standard or specially made to order.)

In these dry colours we do not handle any orders under 5 cwts. single or assorted shades. For export we pack in 10 lb. tins in cases of ten or more, and for Home trade in bags or barrels.

Special prices for wagon-load quantities, delivered to buyers' station.

Telegrams:
"Peters, Derby."
Telephone: Derby, 399.

TOCH BROS.

NEW YORK LONDON TORONTO

THE R.I.W. PROTECTIVE PRODUCTS CO., LTD.

74 Vicarage Lane, London, E.15.
Telephone : Maryland 1589.
Telegrams : Cemenflor, Strat, London.
Branch Offices : Liverpool, Glasgow, Dublin, Swansea, Brighton

---

R.I.W. CEMENT COLOURS For colouring Portland cement construction to produce the richest shades in renderings, stucco, tiles, footpaths and other cement work.

R.I.W. CEMENT COLOURS are supplied only in dry powder form. The decorative shade desired is secured by thoroughly mixing the cement and colour together dry.

Fourteen standard colours are stocked from a variety of sixty attractive shades.

R.I.W. CEMENT COLOURS have been used by the leading architects and engineers for the past 25 years.

R.I.W. TOXEMENT CEMENT WATER-PROOFING COMPOUND used for waterproofing concrete in floors, walls, bridges, foundations, piers, reservoirs, etc.

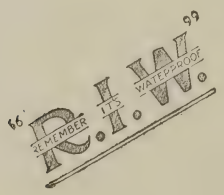
It is a known and accepted fact that the penetration of water will cause concrete to crack and disintegrate, also the reinforcement to rust.

R.I.W. TOXEMENT, added to the mixture, fills the pores and waterproofs the concrete. It lubricates the concrete, causing it to settle in a denser mass and thereby allowing a smaller ratio of water.

TOXEMENTED CEMENT CONCRETE when placed by means of chutes flows more readily and is placed more easily in the forms.

R.I.W. TOXEMENT is used by the leading Government departments throughout the world on account of its reliability.

(*See also pp.* 271, 309 & 310.)



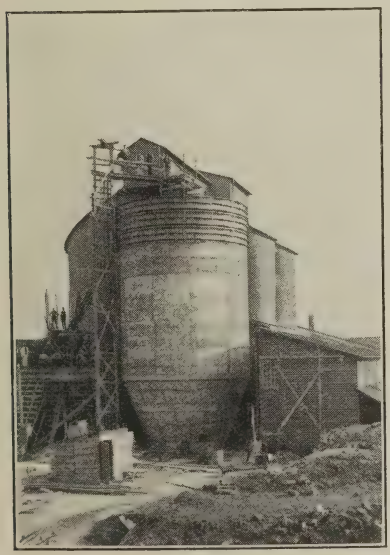
TOCH BROTHERS

ANGLO-DANISH CONCRETE CONSTRUCTION CO., LTD.

7 & 8 NORFOLK ST. LONDON, W.C.2

It is now an established fact that Reinforced Concrete, properly designed and constructed, can be economically employed in structures of almost every shape and form.

Our constructions comprise everything in Reinforced Concrete, ranging from Chimneys, Coal-bunkers, Water-tanks, to Factory Buildings, Large Silos, etc., including DANALITH'S SPECIAL CONSTRUCTIONS.



We shall be pleased to submit estimates for any Reinforced Concrete work contemplated, and, in cases of difficult constructions, our highly skilled and experienced staff will be gladly placed at your disposal for working out designs and making sketches.

The illustration shows Silos for storing Cement, in course of erection; this work was designed and executed by us for Messrs. The Tunnel Portland Cement Co., Ltd., at their works at Grays, Essex.

Illustrated Brochure sent free on application.

Telephone : Central 6138.

Telegrams : "Anglodany, Estrand London."

BAIN & BROWN, LTD.

236, LEITH WALK — LEITH, N.B.

REINFORCED
CONCRETE
ENGINEERS
AND
CONTRACTORS.

We
SATISFY OUR
CLIENTS
with
WORKMANSHIP and
RAPIDITY OF
CONSTRUCTION.

We execute work to any design.

Expert supervision.

Up-to-date plant.

On
Office of Works,
Admiralty and
War Office Lists.

Phone : Leith 346.

Buildings.

Towers.

Bridges.

Sewers.

Roads.

Piling.

Heavy Foundations.

Retaining Walls.

Swimming Baths.

Grain Elevators.

Water-tanks.

Coal-bunkers.

FRANK BEVIS, LTD.

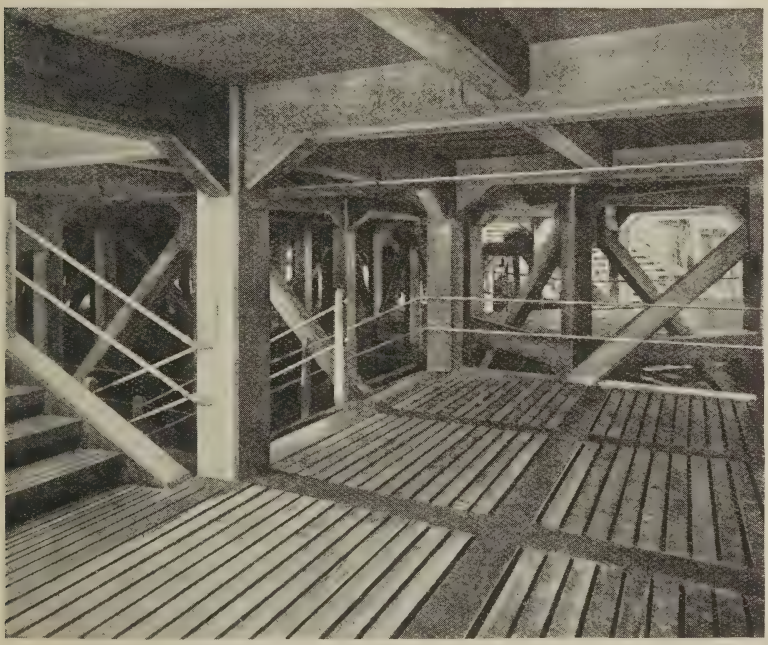
PORTSMOUTH HANTS

SPECIALISTS
IN
REINFORCED
CONCRETE
STRUCTURES.

Thirty years' experience in all classes of work of this character.

Experienced Technical Staff to supervise and carry out Architects' and Civil Engineers' requirements.

As F. B. Ltd. are owners of floating, piling, dredging and ample general plant, also proprietors of Langstone Harbour shingle and grit bank, subaqueous, tidal and general structural work can be dealt with on an economical basis.



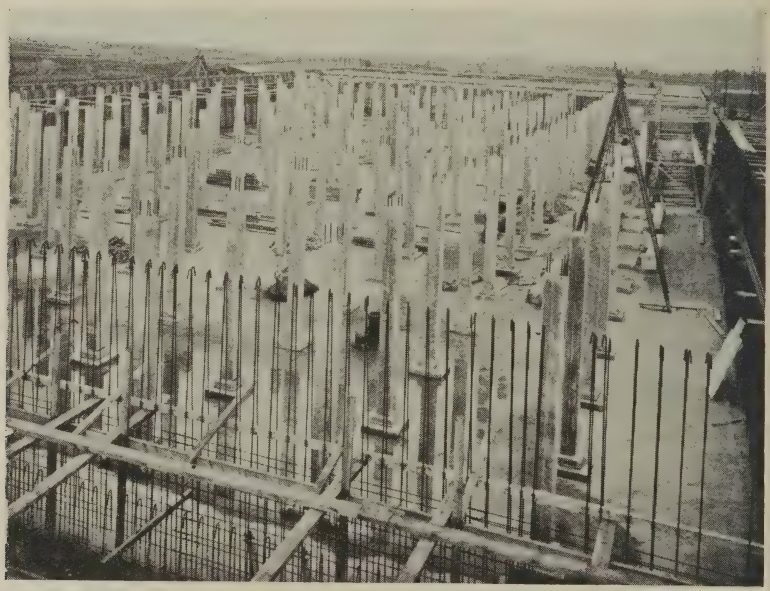
Example of Tidal Pier Work, Ryde Pier, I.O.W.

THE BIRMINGHAM CONCRETE STEEL CO.

125, EDMUND STREET BIRMINGHAM

SPECIALISTS IN THE DESIGN OF REIN-FORCED CONCRETE CONSTRUCTIONS.

Telephone : Central 3273.



3,000,000-GALLON RESERVOIR AT BOURNEMOUTH.

PHILIP G. G. MOON, Esq., Engineer to The Bournemouth Gas and Water Co.

Contractors—Messrs. T. VALE & SONS, LTD., Stourport.

EDMOND COIGNET, LTD.

125, GOWER STREET LONDON, W.C.

The "COIGNET system of reinforced concrete construction has received the highest awards at all the principal international exhibitions.

We specialise in the design of all kinds of reinforced concrete structures.

We are prepared, when required, to quote for the supply of the complete reinforcement, together with working drawings.

Our system of floors has obtained the highest standard of fire resistance of the British Fire Prevention Committee.

———

Telephone: Museum 6497.

Telegraphic Address: Tengioc, Eusroad, London.

"CONCRETE COTTAGES, BUNGALOWS, AND GARAGES"

4, CATHERINE STREET ALDWYCH, W.C.2

BY

ALBERT LAKEMAN,

M.S.A., M.I.Struct.E.

SINCE the first edition of this book was published a very large number of concrete cottages, bungalows, garages, and other smaller buildings have been built, and it is from the experience gained during this period that this new edition has been written. THE second edition is on entirely new lines. The author has specially designed different types of cottages, bungalows, and garages for construction in concrete, and an endeavour has been made to combine a pleasant appearance with the utmost economy.

SECOND EDITION.
ENTIRELY REWRITTEN
ON NEW LINES.

EACH design is accompanied with

PERSPECTIVE DRAWINGS
(*Showing Flat Roof and Sloping Roof.*)
PLANS.
SECTIONS.
FULL WORKING DRAWINGS.
FULL BILL OF QUANTITIES
DESCRIPTION OF METHOD OF ERECTION.
and
HINTS ON CARRYING OUT THE WORK.

READY IN THE SPRING, 1924.

Published by

CONCRETE PUBLICATIONS, LTD.

Editorial Office: 35, Great St. Helens, E.C.3.

Publishing Office: 4, Catherine Street, W.C.2.

DESIGNERS & CONTRACTORS FOR REINFORCED CONCRETE

K. HOLST & CO.

WESTMINSTER CHAMBERS 1, VICTORIA STREET, S.W.1

FERRO-
CONCRETE

Telephone : Victoria 4234.

Telegrams : "Ferrolst, Sowest, London."

Highway Bridge for Herts County Council.

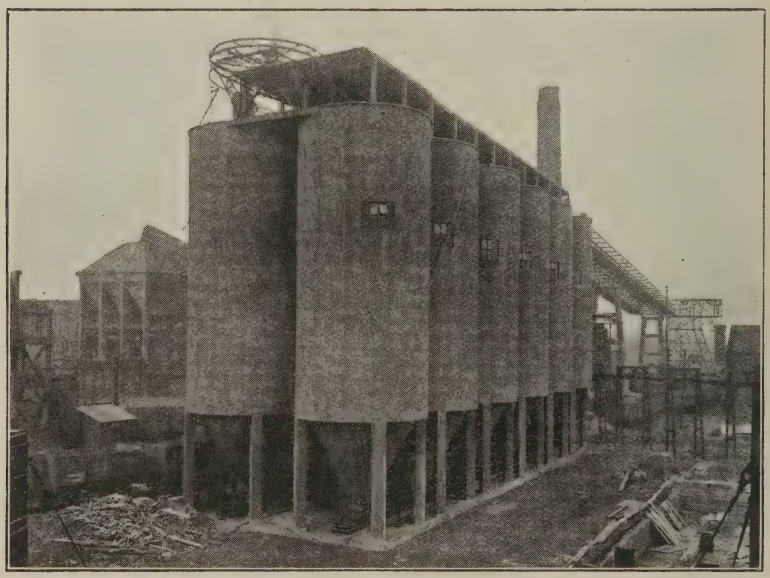
Full responsibility is accepted for both the design and construction of all types of ferro-concrete structures, and their stability is guaranteed.

Preliminary Designs and Estimates for prospective work are submitted free of charge. We invite your enquiries.

Write for brochure.

INDUSTRIAL CONSTRUCTIONS, LTD.
44, GROSVENOR PLACE LONDON, S.W.1

We specialize in the DESIGN AND CONSTRUCTION of every description of REINFORCED CONCRETE WORK.



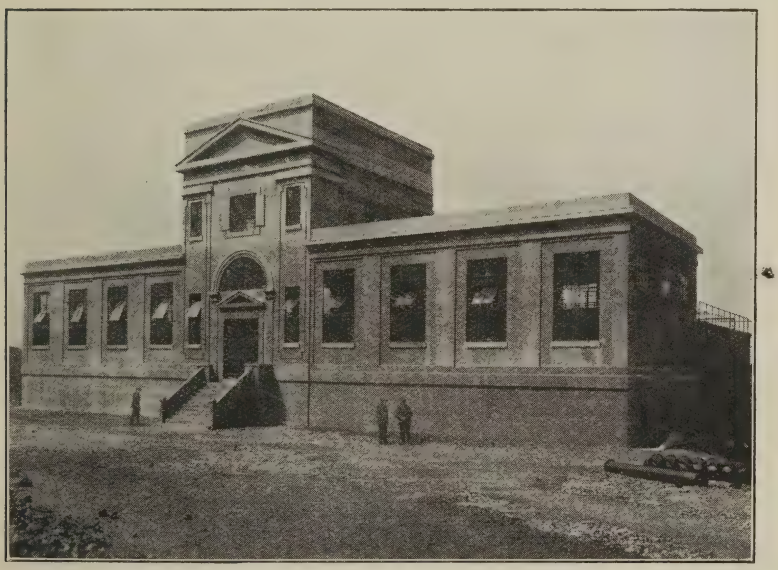
COAL DRAINAGE AND STORAGE BUNKERS, NEW MONCKTON,
for the Monckton Coke and Chemical Co., Ltd.
3,000 *tons Drainage Bunkers.*
300 *tons Storage Bunker.*
Aerial Ropeway Gantry Trestles.

INDUSTRIAL CONSTRUCTIONS, LTD.

44, GROSVENOR PLACE LONDON, S.W.1

Enquiries are invited
and we make no charge
for preliminary schemes
and estimates.

Telegrams: "Refcretcon,
Phone, London."
Telephone: Victoria 6590
(3 lines.)



Filtration Plant, Beckton,
for The Gas Light and Coke Co., Ltd.
Plant designed by The United Water Softeners, Ltd.,
to filter 4 million gallons of Thames Water per day.
Photo shows front elevation
of Filter House.

A. JACKAMAN & SON, LTD.

SLOUGH BUCKS

SPECIALISTS
IN
REINFORCED
CONCRETE.
BRIDGES.
WHARVES & JETTIES.
WAREHOUSES.
PILED FOUNDATIONS, ETC.

WORKS RECENTLY
EXECUTED COMPRISE:

Warehouses and Quays for P.L.A.

Quays at Parkeston and Dock Wall, Lowestoft, for L. & N.E. Rly.

Wharf and Jetty at Portsmouth for H.M. Admiralty.

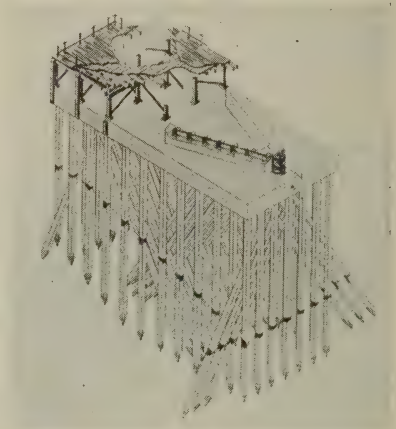
Bridge over River Thames at Goring for Berks and Oxon Councils.

Princes Bridge, Leamington Spa, for Borough of Leamington.

Super Generating Station for City of Birmingham E.S. Dept.

Telephone : Slough 31.
Telegrams : "Jackaman, Slough."

DESIGNS PREPARED
AND ESTIMATES SUBMITTED.



View of one of four Reinforced Concrete Dolphins for Floating Dry Dock at Southampton Docks, S.R. Coy.

Wharf in River Usk, Newport, Mon., G.W. Rly.

CONTRACTORS FOR REINFORCED CONCRETE.

KIRK & RANDALL, LIMITED.

146-7 GROSVENOR ROAD, LONDON, S.W.1

SPECIALISTS
IN
CONCRETE
CONSTRUCTION.

Harbours.
Docks.
Bridges.
Railways.
Tunnels.
Roads and Sewers.
Housing.
Factories.

Telephone :
Victoria 2945 and 2946

Telegrams :
"Vicrandic, Churton, London."

THE "K & R" WHARF is available for loading and unloading purposes, and is situated most conveniently for receipt and delivery of materials in the West End of London.

PETER LIND & CO.

BRUNSWICK HOUSE CENTRAL BUILDINGS LONDON, S.W.1

REINFORCED
CONCRETE
Bridges,
Bunkers and Silos,
Water
Towers and Tanks,
Piling and Raft
Foundations,
Industrial Structures.

Designs and Tenders
prepared
free of charge and
free of obligation
to Architects,
Engineers,
Collieries and
Industrial Firms.

Plain round Mild Steel Bars are used, and as we are ready to carry out work to our designs we assume undivided responsibility.

Latest Catalogue illustrating work designed and erected by us may be had on application.

Careful and prompt attention given to all enquiries.

Telephone :
Victoria 3746 (2 lines).

Telegrams :
" Inneloclin, Phone,
London."

MONNOYER BRITISH CONSTRUCTION CO., LTD.

LONDON · BRUSSELS · PARIS · MADRID

SPECIALISTS IN REINFORCED CONCRETE STRUCTURES.

1. INDUSTRIAL.

Central Power Stations.
Collieries Pitheads.
Blast Furnaces Foundations,
Cowper Tower Foundations,
Cooling Tower Foundations.
Coal and Ore Handling Bridges.
Chemical Works, Breweries, Warehouses, etc.

2. ARCHITECTURAL.

Town Halls.
Churches.
Baths.
Cinemas.
Concert Halls, Theatres.
Hotels.
Banks.
Schools.

3. PUBLIC WORKS.

Quay Walls, Sea Walls, Jetties.
Piers, Moles, Locks, Canals.
Footbridges, Highway Bridges, Railway Bridges.
Water Towers.
Service Reservoirs.
Roads.

Thirty years of world-wide experience in reinforced concrete work.

ADDRESSES.

ENGLAND:

6, New Burlington Street,
Regent Street,
London, W.1.

Telephone: Gerrard 6977.
Regent 3253.

Cables: " Reyonnom, London."

BELGIUM:

1, Rue Camille Lemonnier,
Bruxelles.

FRANCE:

127, Rue du Faubourg St. Honoré,
Paris (viii^{E}).

SPAIN:

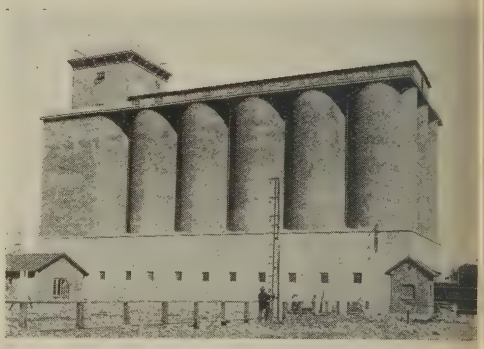
1, Avenida del Conde Penalver,
Madrid.

SAXILD & PARTNERS

2, CENTRAL BUILDINGS WESTMINSTER LONDON, S.W.1

REINFORCED
CONCRETE
FOR
ALL CLASSES
OF
BUILDING
CONSTRUCTION.

FACTORY
BUILDINGS.
WAREHOUSES.
GRAIN SILOS.
OIL STORAGE
DEPOTS.
ELECTRIC POWER
STATIONS.
FOUNDATIONS.
ETC.



Reinforced Concrete Grain Silo.

In the course of the past years we have carried out a large number of reinforced concrete structures for all purposes, and we have developed several methods of design and types of construction which have many advantages over those usually adopted.

Everyone interested in the design and construction of reinforced concrete should write for a copy of our new catalogue "C.Y." which will be sent on request. This catalogue depicts a large number of reinforced concrete structures of various types, and will prove of interest to anybody concerned in reinforced concrete work.

Estimates given for any class of reinforced concrete work.

Telephone : Victoria 7121.

Telegrams : "Saxconcret, Phone, London."

SAXILD & PARTNERS

2, CENTRAL BUILDINGS WESTMINSTER LONDON, S.W.1

MARITIME WORKS
IN
REINFORCED CONCRETE.

QUAY WALLS,
JETTIES,
BREAKWATERS,
SEA WALLS,
ETC.

We have carried out a very large number of maritime structures in reinforced concrete, and have developed several methods of construction which make for economy and rapid construction.

Send for illustrated catalogue "C.Y."

Telephone: Victoria 7121.
Telegrams: "Saxconcret, Phone, London."

Breakwater built of Reinforced Concrete Caissons

ANDREW SCOTT

PORT TALBOT — SOUTH WALES

Telephone : 42 Port Talbot.

Telegrams : " Scott, Contractor, Port Talbot."

CIVIL ENGINEERING, MINING, REINFORCED CONCRETE.

ALL CLASSES OF CIVIL ENGINEERING WORKS UNDERTAKEN.

SPECIALIST IN REINFORCED CONCRETE, MINING, PITS, SLANTS, PIT BOTTOMS, LINING MAIN ROADS, HAULAGE RAFTS, HEADINGS, ETC. GANTRIES, SCREENING PLANTS, BUNKERS, TANKS, FAN DRIFTS, SURFACE BUILDINGS, RAILWAY SIDINGS, ETC.

TOPPING & LEGGAT

51, TOTHILL STREET WESTMINSTER LONDON, S.W.1

REINFORCED CONCRETE CHIMNEYS.

The Concrete Chimney has proved itself a working proposition, especially where the soil has a low bearing capacity and lightness is an essential. The cost of maintenance is practically *nil*—no pointing is periodically required as with a brick stack, and the first cost compares favourably with that of the brick chimney.

The concrete stack is superior to that of steel—the latter possessing a relatively short "life" and requiring constant attention by way of scraping and painting every few years.

At the same time the full advantage to be secured by the adoption of a concrete chimney can only be obtained by placing the design and erection in the hands of experienced practical specialists who realize to the fullest extent the practical and theoretical considerations necessary to ensure an efficient unit.

We are always pleased to visit the site of a proposed stack and put forward recommendation, design and tender for a stack to meet clients' requirements. We have our own staff of practical chimney erectors and can quote a keen price for a first class job.

We also design and erect

BRICK CHIMNEYS.

BRANCH OFFICES :—

Swansea : Prudential Chambers, Castle Street.

Glasgow : 179, Hope Street.

Sunderland : Maritime Chambers, St. Thomas Street.

Manchester : 23, Fountain Street.

HEAD OFFICE :—

Telephone : Vic. 5347.

Telegrams : "Smokechim, Parl, London."

EDWIN WAIT

NORTH END EAST WOODHAY, NEWBURY BERKS

Reinforced Concrete Bridge, Donnington Grove, Newbury, Berks.
Designed and Constructed by Edwin Wait, 1923.

SPECIALIST
IN
FIRE-RESISTING
AND
REINFORCED
CONCRETE
CONSTRUCTION.

Manufacturer of :—
CONCRETE RICK STANDS,
FENCING POSTS,
KERB, CHANNELS,
EDGING TILES,
ORNAMENTAL PANELS,
BALUSTRADES, LINTELS,
DOOR AND WINDOW HEADS AND SILLS,
PIG TROUGHS,
WATER CISTERNS, DRINKING TROUGHS,
PAVINGS,
PARTITION SLABS, etc., etc.

WELLERMAN BROS., LIMITED

223, ATTERCLIFFE ROAD — SHEFFIELD

Telephone :
Sheffield 2518.

Telegrams :
Wellerman, Sheffield,
2518.

And
EDWARD STREET,
HYDE,
Near Manchester.

Telephone :
Hyde 58.

ESTABLISHED 1889.

ESTIMATES GIVEN
FOR ALL
CLASSES OF
CONCRETE
CONSTRUCTION

W. H. WORTHINGTON, LIMITED

61, RUSHOLME ROAD — MANCHESTER

Established 1830.

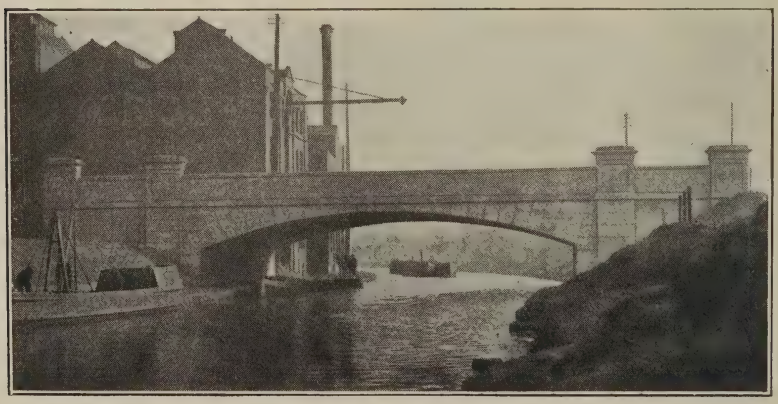
REINFORCED CONCRETE CONSTRUCTION OF ALL CLASSES.

Works executed include the following :—
Reservoirs,
Swimming Baths,
Water Softening Tanks,
Sludge Tanks,
Bunkers,
Silos,
Retaining Walls,
Bridges,
Warehouses,
Mills,
Tramway Sheds,
Chemical Plant,
Gas Works Plant,
Foundation Rafts,
Piling,
Reinforced Concrete Roads.

British Mild Steel Bars provided and bent to any specification.

Telegraphic Address:
"Flagging, Manchester."

Telephone Numbers:
Central 2957 and 2958.



COLUMBIAN FIREPROOFING CO., LTD.

WINDSOR HOUSE VICTORIA STREET LONDON, S.W.1

A DEPENDABLE FLOOR

No. 419 Oxford Street, W.1. Architect: G. Thrale Jell, Esq., A.R.I.B.A.

The whole of the Fireproof Floors and Roof of No. 419, Oxford Street, W.1 (illustrated above), comprising 27,740 ft. super were laid on the "COLUMBIAN" system.

Telephone: Victoria, 4089.

ENQUIRIES INVITED

HORACE W. CULLUM & CO., LTD.

50-52, BRITANNIA STREET KING'S CROSS, W.C.1

"CULLUM" FLOORS

are an IMPROVEMENT on the usual type of HOLLOW BLOCK FLOORS.

Large Numbers of Architects for whom we have carried out work will gladly confirm this statement.

THE V JOINT MAKES A STRONG JOB.

We shall be pleased to prepare a scheme for any job and to carry any load.

Best materials only used and stressed in accordance with L.C.C requirements.

Phone : Museum 1797.

Wires : "Kulmco, Kincross, London."

Code : ABC 5th Edition.

SOME CONTRACTS CARRIED OUT BY US :—

P. & O. Offices, Leadenhall Street, E.C.

Messrs. Fullers, Ltd., Regent Street, W.

Great Northern Telegraph Offices, St. Helen's Place, E.C.

New Glass Works, Chesterfield.

ST. MARY'S Hospital additions, PLAISTOW.

Metropolitan Railway, Farringdon Street, and Wembley Park Stations.

Butler's Wharf Extension, Shad Thames, etc., etc., etc.

J. & W. STEWART

12, BERKELEY STREET LONDON, W.1

The STEWART HOLLOW CONCRETE FLOOR is the outcome of a long experience in constructing concrete floors. Price is not sacrificed to strength, and we claim that on its merits there is no cheaper floor obtainable.

TEMPORARY TIMBER SHUTTERING is eliminated.

ERECTION is rapid, as several floors can be completed at the same time.

WIDE RANGE OF VARIOUS SIZED BLOCKS reduces concrete mixed on the site to a minimum.

REINFORCEMENT cannot be displaced and bars are visible before concrete is laid.

SOUND-RESISTING AND FIREPROOF to pass 1A Standard of the Fire Offices Committee if necessary.

DESIGNS as required TO L.C.C. REGULATIONS, R.I.B.A. Specification or Local Conditions.

DEAD WEIGHT is exceptionally low, thus reducing the cost of beams and columns and the loads on foundations, etc.

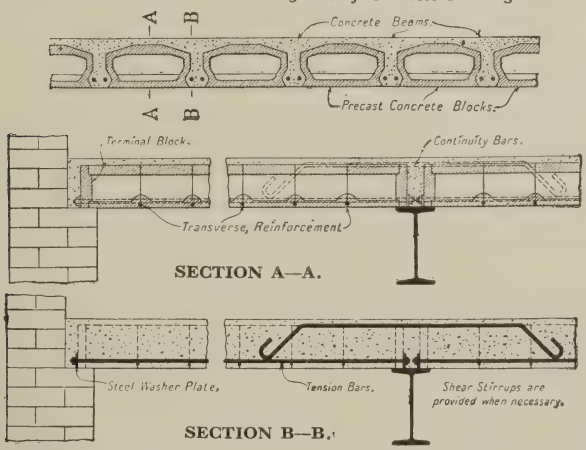
ADAPTABLE for openings and trimmings to offsets, splayed walls, or reconstruction.

SOFFIT is flat and roughed for plaster, and can be left for limewashing only.

TESTS. A recent certified test on two 15 ft. spans with 4 ft. 6 in. cantilevers, for a specified load of 3 cwt. per square foot, and a deflection limited to 1/600th of the span gave a load of 6 cwt. per square foot, and a deflection of 1/1500th of the span without any fractures or cracks.

GUARANTEED SAFE FLOORS are a feature in which we specialize.

Use the Stewart H. B. System of Concrete Flooring.



Established 1874.

ALSO AT BELFAST AND DUBLIN.

Mayfair 306–8. "Cymplecks, Piccy, London."

Specialists in the Construction of Reinforced Concrete Storage Tanks, Bunkers, Silos, Industrial Buildings and Bridges.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

ABRASIVE MATERIALS AND FLOORING GRAINS.

All Concrete firms laying floors, etc., where long life and high resistance to wear are desired, should use our special surfacing materials expressly produced for these uses, and marketed at a price to encourage their universal use in factory floors, docks, yards, paving flags, pathways, doorsteps, stair-treads, etc.

The materials available are of two types. One is we believe the hardest natural rock available in any part of the world, and which does not crack or crumble even under the very heaviest and roughest usage in concrete as granites and other materials will. The other artificial abrasive is related to the well-known products like Corundum, etc.

They are both available in all sizes from meal to large grains, and in addition to their uses in the work already named, they may be used in the manufacture of Concrete Grindstones, Whetstones, Safety Tread Tiles, etc.

We shall be pleased to send you a range of samples on request and to point out the most suitable size and material for the work you propose to use them on, as well as to give you any necessary help in case you wish to make special products with these grains.

CEMENT INDUSTRIES
SIDDALS ROAD WORKS DERBY

For
MOSAIC CUBES
TERAZZO
GRAINS
and the other
NECESSARY
MATERIALS
for this
FLOOR
SURFACING.

Ask us for Prices
and
Samples.

Cubes and grains are shipped direct from quarries only, and subject to minimum orders of 10 tons.

VERDURA HARD COURT CO.

DERWENT CHAMBERS DERBY

FLOORING CONTRACTORS FOR TENNIS COURTS, OPEN-AIR SKATING RINKS AND OTHER SPECIAL CEMENT FLOORS.

The chief advantages of our Tennis Courts are :—

Reasonable First Cost.
Absolutely no Upkeep expenses.
Permanent, and will wear for a lifetime.
Is a restful (green) Colour.
May also be had in various tones of green.
Has permanent inlaid White Cement lines.
Colours will never fade or alter.
Constructed with Special Cement.
All other materials are local and very cheap.
Has a resilient Foundation.
The surface is perfectly flat and true.
It allows rain to percolate as through a filter.
Will permit play during a shower or immediately after rain.
Will not dirty the balls or make them heavy with mud.
Gives perfect bounce to ball.
Permits the fastest possible play.
Gives perfect grip to feet.
Cannot splash mud, slush, water, dust, or grit about, as there is none.
Will not unduly wear out the balls.
Requires no watering, no top-dressings and no attention of any sort.
Is unaffected by extremes of temperature.
Has full provision made in its method of construction for expansion and contraction.
Is endorsed by Clubs, Y.M.C.A.'s, Hotels, Public Authorities, etc., everywhere these types of courts are used.
Produces the best and fastest players.

Even the big Wealthy Clubs in U.S.A., etc., put down one of this type of Court for professionals, as they are available when no others can be played upon.

We shall be happy to do this work either for the customer and buyer, or for the Trade, and can either find all the labour or the Foreman only, in either case guaranteeing the result.

Send for particulars.

CEMENT INDUSTRIES
SIDDALS ROAD WORKS DERBY

FIRMS
REQUIRING
SPECIAL
CONCRETE
FLOOR
LEVELLING
AND
FINISHING
MACHINE
FOR

TENNIS COURTS,
FACTORY FLOORS,
SIDEWALKS,
OR ANY
FLAT
WORK
OF
LARGE
AREA
ARE
REQUESTED
TO
CORRESPOND
WITH US

ALLIED MACHINERY CO., LTD.

70, VICTORIA STREET WESTMINSTER, S.W.1

THE "LAKEWOOD" ROAD FINISHER.

(*Illustrated on next page.*)

The machine that spreads, tamps and surfaces the concrete.

"ALMACOA."

The "LAKEWOOD" ROAD FINISHER provides a mechanical means of spreading the concrete on large areas, such as concrete roads, yards, warehouse floors, etc., and, where roads are concerned, to the proper crown for the road slab; of tamping the concrete to eliminate air and water voids, and compacting the aggregate into a dense slab of maximum strength. It finishes the surface to the exact contour to produce a true even riding road.

The machine travels backwards and forwards on forms under its own power, which is applied from the engine to all four wheels.

All operations of the Finisher are controlled from either side of the road by a simple arrangement of duplicate levers. These levers control the vertical movements of the strike-off and tamper, as well as the clutches which drive them and the traction mechanism.

Only one operator is required for the machine, which is equipped with a 5 h.p. air-cooled engine.

The 1923 model is equipped with several new and important features, such as an adjustable strike-off, a new and improved Pitman box assembly, and several other refinements which give improved service. Road wheels for transporting the machine behind a lorry, thus affording a convenient method of moving the assembled machine, can be provided.

We supply Carr steel road forms, for use with the above machine, simple in design and strong in construction, easily laid down and taken up. Maintenance cost of forms is negligible.

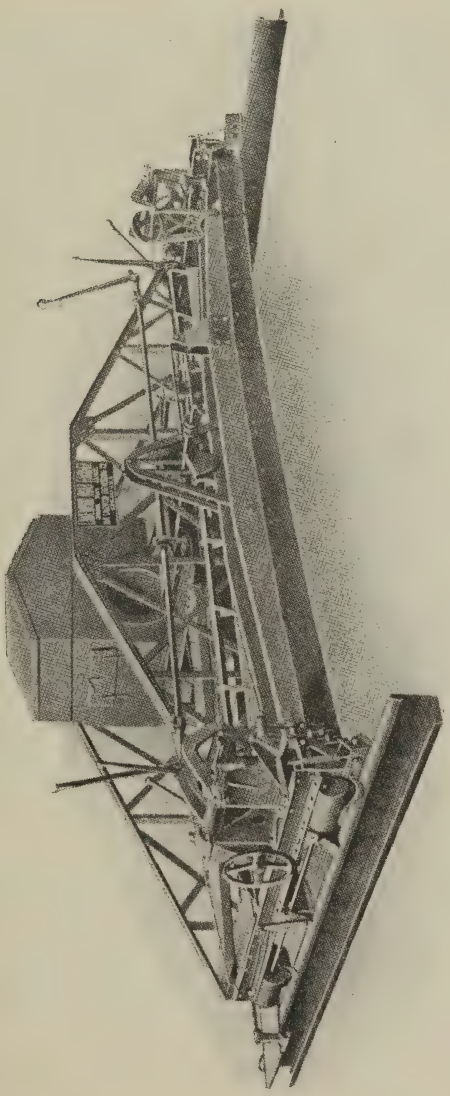
We also supply concrete pavers, concrete mixers, concrete chuting equipment, bucket loaders, portable conveyors, and every type of machinery used by municipal engineers and contractors.

Write for catalogues and particulars.

Telephone: Victoria 1813–4.

ALLIED MACHINERY CO., LTD.

70, VICTORIA STREET WESTMINSTER, S.W.1



The "Lakewood" Road Finisher.
(This machine is fully described on the preceding page.)

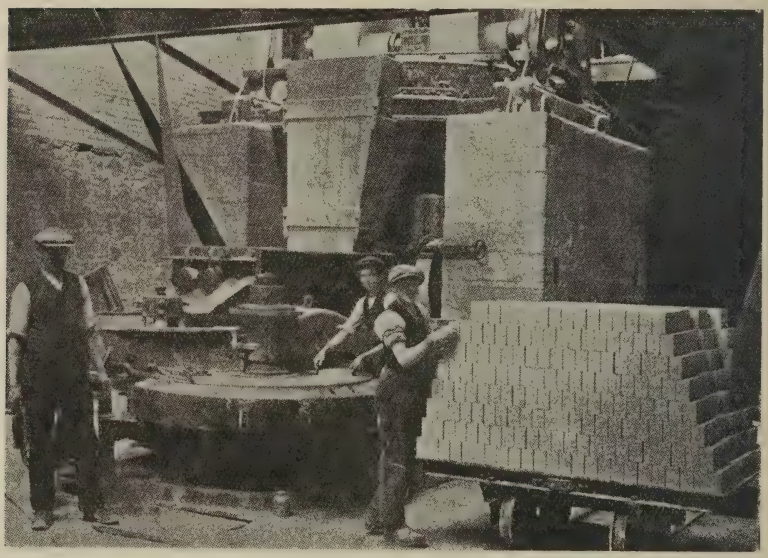
HERBERT ALEXANDER & CO., LTD.

CHARMOUTH STREET LEEDS

LONDON OFFICE :
12, Broadway,
Westminster,
S.W.1

LEEDS :
Telegrams : "Alexson, Leeds."
Telephone : Leeds 23274

LONDON :
Telegrams: "Exandraler, Phone, London."
Telephone : Vic. 6969–70.



Concrete or Sand-Lime Brickmaking Plant embodying our world renowned "Hercules" Press.

We manufacture Machinery for
All Processes of Brickmaking, for
Hand, Animal or Power.
Patent Sand Ore and Coal Drying Plant.
Grinding, Crushing and Pulverizing Plant.
Measuring and Mixing Machines.
Elevating and Conveying Plant.

ATLAS DIESEL COMPANY, LTD.

35, SURREY STREET LONDON, W.C.2

Telegrams: "Dieselmot, London." *Telephone:* Central 9067.

"Atlas" Concrete Breakers at Work in London.

Complete Quarry and Mine Equipments.
Rock Drills of all types.
Columns, Tripods, Hose, Couplings, etc.
Drill Steel Sharpening Machines and Tools.

Road Repair Tools, including:
Concrete Breakers, Picks, Tampers, Clay Diggers; Steels, Accessories.

Stationary Diesel Engines to 1100 H.P.
Crude Oil Engines to 120 H.P.
Compressor, Pumping and Electrical Sets.

Stationary Air Compressors to 3500 c.f.
Portable Air Compressors to 144 c.f.

Pneumatic Tools for all Purposes.

A. A. BYRD & CO.

11, QUEEN VICTORIA STREET LONDON, E.C.4

CIRCULAR-FLEXIBLE METAFORMS are adjustable to mould ANY RANGE OF DIAMETERS for SILOS, CHIMNEYS, TANKS, FILTERS, etc.

A PERFECTLY SMOOTH SEALED FACE TO THE CONCRETE IS ASSURED.

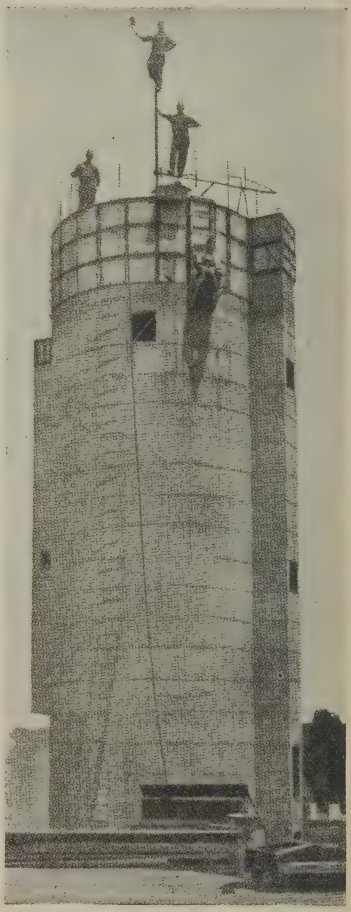
These light and very easily portable steel forms are so constructed that they are flexible and will conform to any desired diameter according to the size of the angle-iron ring used, which in turn is held to a true circle by arms which radiate from a centre mast.

A Typical 3-Course Silo Outfit with Derricks.

Standard Silo Outfits are supplied complete with DERRICK AND POURING PLANT—so that the concrete is placed direct from Mixer to Forms without handling.

A PERFECT TAPER is easily obtained by the use of the ADJUSTABLE SECTIONS—no other steel forms on the market will do this!

A TRUE PLUMB WATERTIGHT JOB IS GUARANTEED AT A VERY LOW COST WITH METAFORMS.



A Metaform Silo Outfit in Use.

A. A. BYRD & CO.

11, QUEEN VICTORIA STREET LONDON, E.C.4

METAFORMS are the most widely used STEEL SHUTTERING for rapidly moulding Mass or Reinforced Concrete Structures of any type or size.

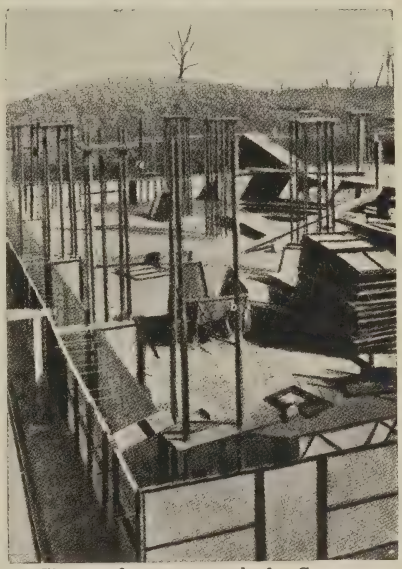
NO TIMBER STRUTS OR BRACES USED—THEY KEEP A TRUE PLUMB LINE.

The standard unit is a light steel plate 24 in. × 24 in. reinforced with angle iron —there are fifteen other sizes, also three types of corner connections. All units are made to slide together and interlock with quick-acting clamps attached to each unit.

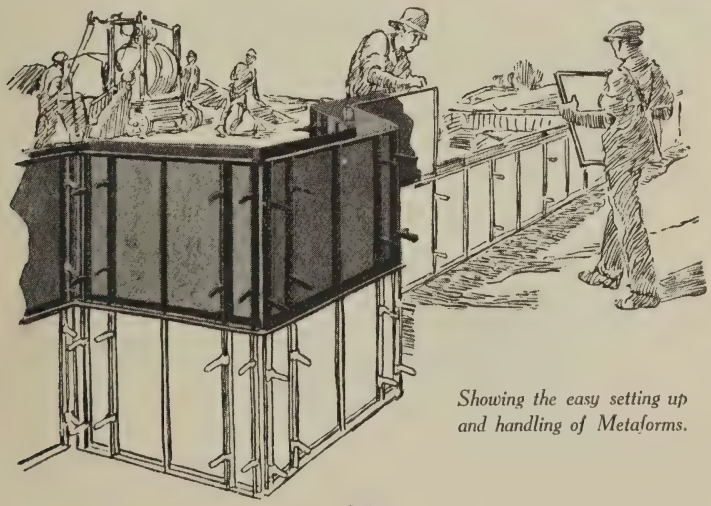
THUS ANY FORM, ANGLE, PROJECTION OR RECESS IS QUICKLY SET UP OR STRIPPED.

PERFECTLY SMOOTH FINISH CONCRETE.

ONE OUTFIT WILL EARN PROFITS FOR YEARS. USE METAFORMS AND CUT COSTS.



Showing first course ready for Concrete.



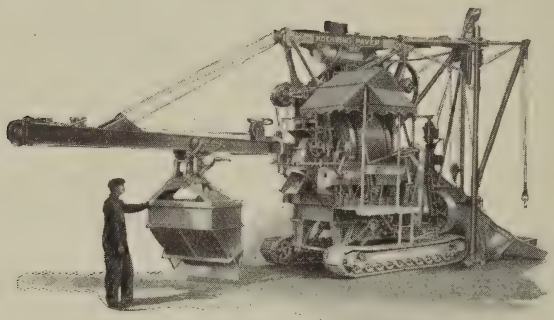
Showing the easy setting up and handling of Metaforms.

A. A. BYRD & CO.

11, QUEEN VICTORIA STREET — LONDON, E.C.4

KOEHRING CONCRETE MIXERS —AMERICA'S BEST.

KOEHRING MACHINES ENSURE PERFECTLY MIXED UNIFORM STRENGTH CONCRETE IN EVERY BATCH.



Koehring 21-E Paver.

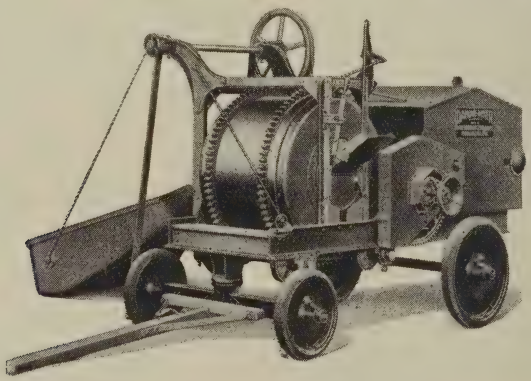
These machines provide the most efficient and rapid Street Paving equipment for all round continuous heavy duty in the construction of concrete roads.

CENTRALISED CONTROL OF ALL OPERATIONS!

Water supply under positive control in auto-tank.

The "KOEHRING" five-in-one mixing action ensures the constant showering and cascading of the aggregates, whilst sturdy blades break up any accumulated masses.

KOEHRING MACHINES ARE IN USE WITH MANY COUNTY COUNCILS AND CONTRACTORS, ETC., ALL OVER GREAT BRITAIN.



No. 104 "Dandie" on Rubber-Tyred Wheels.

THE CHALMERS-EDINA CO.

39, ASSEMBLY STREET LEITH SCOTLAND

The EDINA No. 9 Concrete Mixer, having a capacity of 3 cub. ft. of mixed material per batch, and with an output of from 20 to 30 cub. yds. per 8 hours' day at the cost of ½ to ¾ gallon of petrol, is a proposition that has been eagerly taken up by all the principal Builders and Contractors in this country.

It does work equal to big machines costing many times its price, and owing to the ease with which it can be moved about from site to site, many contractors are substituting one or more "EDINAS" in place of the more cumbersome and dearer priced machines. In one large English city over forty of these machines have been supplied during the last few months.

It is practical, thoroughly reliable and durable, and discharge tilts in opposite direction to loading.

No other Mixer of its size excels the quality of its work, and the remarkably low price beings it within reach of all.

GENERAL SPECIFICATION OF NO. 9 MIXER.

FRAMEWORK.—Rolled Steel and Wrought Iron throughout.

MIXING DRUM.—Body, 12-gauge Steel; Bottom 10-gauge Steel, pressed from solid and riveted in.

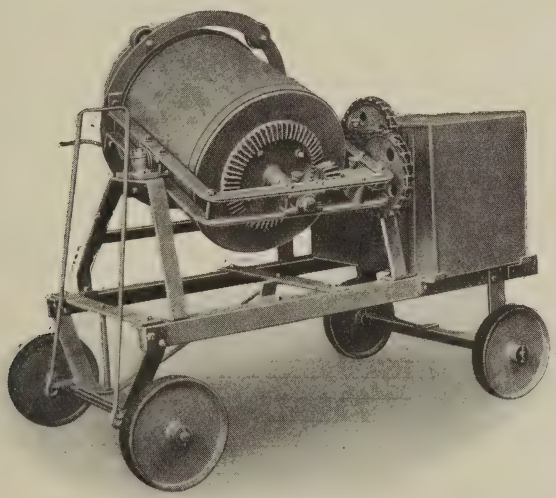
DRIVES.—Chain throughout with clutch on Engine shaft.

ENGINE.—Petrol, solid British built, Hopper Cooled, with Magneto Ignition.

ENGINE HOUSING.—Steel Sheet.

TOTAL WEIGHT.—11 cwts.

Write for new illustrated leaflet C.M. 1/10/23, also describing our latest No. 10 POWER DRIVEN MIXER, capacity 6 cub. ft. mixed material per batch or 60 cub. yds. per 8 hours' day.



No. 9. "EDINA" BATCH MIXER. CAPACITY 3 CUB. FT. MIXED MATERIAL PER BATCH.

COWAN HULBERT

423, ABBEY HOUSE WESTMINSTER LONDON, S.W.1

THE PIONEERS

CONCRETE-PLACING
TRADE INSLEY MARK
EQUIPMENT

INSLEY Engineering Service is at the command of Contractors and Engineers in the design of Plant Lay-outs, involving either Standard or Special Equipment.

We solicit an opportunity to go into your concrete and material handling problems with you.

We may be able to make suggestions that would be of value to you.

INSLEY Concrete Distribution Equipments as well as Insley Engineers occupy the foremost position in their line.

We have equipments for all Concrete handling problems.

BRITISH MADE.
LARGE STOCKS.

ENGINEERING
INSLEY
SERVICE

Consult us on your Concrete placing problems, whether large or small.

Seventeen years' experience in Concrete Chuting Plants.

COWAN HULBERT

423, Abbey House, Westminster, London, S.W.1.

Telephone : Victoria 8938.

Telegrams :
" Snugly, Sowest, London."

THE CYCLOPS CONCRETE CO.

9–11, HILBRE STREET LIVERPOOL

BLOCKS MADE FROM BOILER ASHES.

A house built of Cyclops Blocks made with Boiler Ashes cannot be damp, as Capillary attraction does not take place.

THE CYCLOPS CONCRETE COMPANY have been making Cinder Blocks for nearly twenty years, but this invention was patented as a new production a few years ago in America, and has proved a great success. The American Government tested the qualities of the material against fire. It was found that furnaces built with 5 in. Cinder Slabs when heated to 1,700° Fahr. did not disintegrate, and when water was thrown on the incandescent slabs the only effect produced was a slight dust on the surface, which was readily brushed off. When the furnace was at its greatest heat the hand could be placed upon the outside of the slab, as the temperature was only 120° Fahr.

THE CYCLOPS CONCRETE COMPANY last year built a Large House in Birkenhead Park with Cinder Blocks—the following Testimonial received from the Owner speaks for itself :—

J. S. RIGBY, ESQ., CYCLOPS CONCRETE CO.

July 3, 1923.

Dear Sir,—

In response to your enquiry, I would certify that our house, 7, Forest Road, built by you five months ago of your hollow concrete blocks, has given pre-eminent satisfaction. It is the driest house without exception I have known after having been built, for we got in before the carpenters were out, and we never saw the smallest trace of damp, or any ill effects of it.

Yours truly,

(*Signed*) W. P. THOMPSON.

CONCRETE BLOCKS *v.* BRICKS.

100 Bricks to one square yard of 9 in. wall can be set in 80 minutes by one Bricksetter and Labourer.

The equivalent to the above in Concrete Blocks can be set in 45 minutes.

Average cost of bricks per hundred, about 7*s.*

Average cost of blocks (8 blocks), about 4*s.* 8*d.*

One Bag of Cement will make 20 Blocks with 6 to 1 and 2 to 1 faces. 1,000 blocks can be made in one week.

	£	*s.*	*d.*
Cost of Sand	2	0	0
Cost of Ashes . . .	4	0	0
Cost of Labour . . .	9	0	0
Cost of Cement . . .	15	10	0
	£30	10	0

Bricks cost £3 5*s.* per thousand.

1,000 Blocks which cost £30 10*s.* are the equivalent of 12,500 Bricks which cost £40 2*s.* 6*d.*

About 1,000 Blocks will build a Bungalow, and with a CYCLOPS MORTAR GAUGE unskilled Men can do the building.

Write for our illustrated Catalogue relating to our System of Construction and particulars of our machinery for all kinds of concrete work.

Telegrams : "Assessor, Liverpool."
Telephone : Royal 1195.

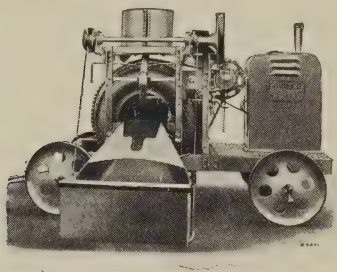
JOHN FOWLER & CO. (LEEDS), LTD.

HUNSLET LEEDS

CONCRETE MIXERS.

The " FOWLER " No. 10/7 Concrete Mixer, as illustrated, is capable of turning out 7 cubic ft. of MIXED concrete per batch, and is complete with Paraffin Engine and Power Loader.

The GENERAL FRAME CONSTRUCTION is absolutely rigid.



Pressings have been adopted in the underframe and the usual angle cleats and corner plates have been eliminated, thus considerably lessening loose frame connections.

The WHEELS are of pressed steel, this type being adopted to prevent trouble of bedding in with overflow concrete.

The MIXING DRUM is of unique design, semi-cast steel being used for the centre, where the maximum mixing and consequent friction takes place, and light pressed steel side plates where there is considerably less wear and tear.

The SIDE PLATES are curved inwards at the opening to prevent splashing.

The DRUM is rotated by chain from the countershaft, the rotating pull being upwards, thus assisting in reducing the weight on the tracker wheels.

There is an automatic attachment to prevent overwinding of the charging skip.

The WATER TANK is fitted with a rapid release valve with marked regulator and special filling valve.

There are many other exclusive " Fowler " features.

We also manufacture Mixers with capacities of 4, 14, 21, 28 and 56 cubic feet of MIXED Concrete per batch.

Write for full particulars.

WE GIVE WILLING SERVICE
WITH NO OBLIGATIONS

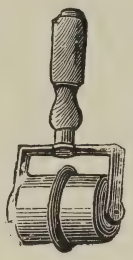
FOWLER LEEDS.

ALEXANDER GILCHRIST

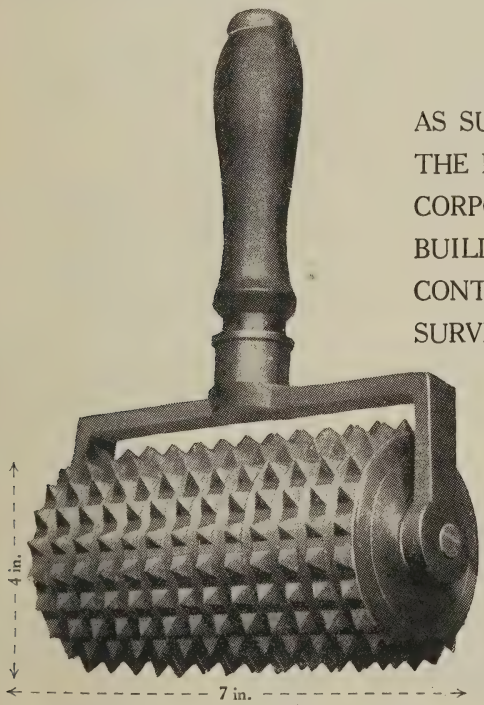
25, EGLINTON STREET GLASGOW

BRASSFOUNDER.

Makes a speciality of Brass Patent CONCRETE ROLLERS, GROOVERS, STAMPS and NAME PLATES for CONCRETE, GRANOLITHIC, TAR, and ALL KINDS OF ARTIFICIAL PAVING.



Jointer Roller.



Pyramid Teeth Roller for indenting cement. Teeth cut out of Solid. Made up to 24″ in length.

AS SUPPLIED TO ALL THE PRINCIPAL CORPORATIONS, BUILDERS, CONTRACTORS AND SURVEYORS.

Telegraphic Address :
"Grooves, Glasgow."

ESTABLISHED 1851.

SEND FOR ILLUSTRATED LIST.

PARKER, WINDER & ACHURCH, LTD.

BROAD STREET BIRMINGHAM

MAKING THE SMALL JOB PAY

"For small jobs to which it does not pay to transport high-power mixers the EMPIRE MIXER proves far more satisfactory and convenient—portable, all metal, complete with engine on 4-wheel truck."—*Contractors' Record.*

As a paying proposition the "EMPIRE" All-Metal CONCRETE MIXER instantly recommends itself to the contractor's practical mind. In speed, portability and clean mixing it measures up to all his requirements and widens the profit margin on many a job.

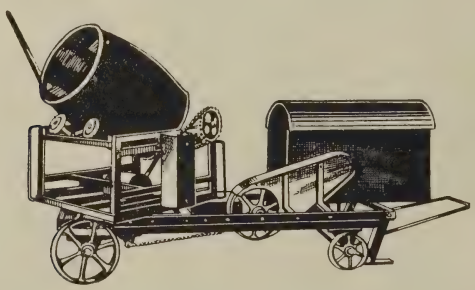
Messrs. A. H. Guest, Ltd., Concrete Constructors, Stourbridge, having thoroughly tested an "EMPIRE" All-Metal CONCRETE MIXER report: 80 ft. run of Foundations $3\frac{1}{2}$ ft. wide, concrete 15 in. to 24 in. thick.

Time taken for the above by No. 12 "Empire Mixer" was $4\frac{1}{2}$ hrs. 80 ft. $\times$ $3\frac{1}{2}$ ft. $\times$ $1\frac{1}{2}$ ft. $=$ $80 \times 5\frac{1}{4} = 420$ cubic ft. 420/27—15.5/6 cubic yards in $4\frac{1}{2}$ hours. Taking 1 cubic yard of wet concrete as equalling 27 ct. 15.5/9 cubic yds. $=$ 21 tons. Therefore above performance shows an output of 3.4/9 cubic yards or 4.2/3 tons per hour for No. 12 "Empire" Concrete Mixer in question.

Write for our free list E.M. 332.

PARKER, WINDER & ACHURCH, LTD., Concrete Machinery Manufacturers, Birmingham.

London: 40, Craven Street, W.C.2.



RANSOME MACHINERY CO. (1920), LTD.

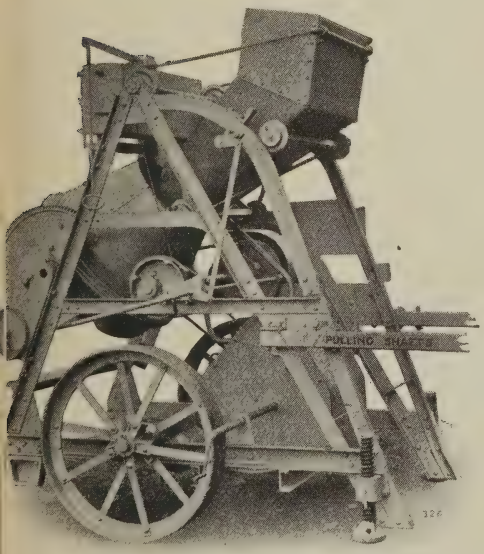
DEPT. 7, 14-16, GROSVENOR GARDENS LONDON, S.W.1

RANSOME

ALL BRITISH

1182

The mark of the make that LASTS and of the WISE buyer's choice.



RANSOME LIGHTWEIGHT RUNABOUT MIXER, THE BEST VALUE IN MIXERS ON THE MARKET.

MIXERS in all models and sizes to suit all requirements.

STEEL TOWER and CHUTE PLACING PLANTS for saving time and labour.

CONCRETE MOULDING PRESS for making blocks of all kinds, tiles, etc.

TWO-WHEEL TIP-CART.

Also STEEL PILING and PILING PLANT and TAR MACADAM and ASPHALT PLANT.

THE BEST SMALL MIXER is the Ransome Lightweight illustrated. Two large wheels and balance make it exceptionally portable. Self-contained with elevating skip (7 cu. ft.), water tank and 3 h.p. petrol engine, mixed batch 5 cu. ft., 40 batches per hour, output 7·5 cu. yd. concrete per hour—*properly* mixed. Very strongly built to LAST, yet quite low priced.

"AERO" New Method of Concrete Production which results in better concrete at less cost.

Largest Manufacturers of High-class Concrete Machinery in the British Empire.

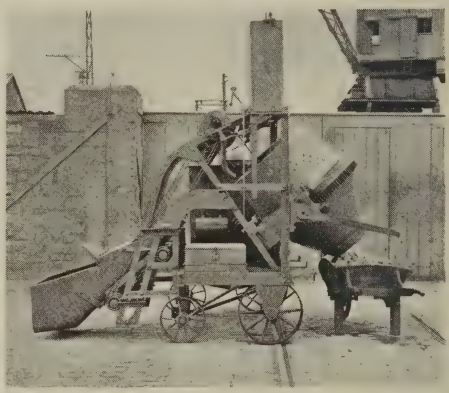
STOTHERT & PITT, LTD.

MIXER DEPT. BATH

The well-known Victoria Mixer, which is manufactured by Stothert & Pitt, Ltd., at their works at Bath, is made in a very wide range of capacities so that the Contractor can always find one size to meet his requirements.

The machines are supplied to give the following quantities of mixed concrete in cubic feet per batch :—

3, 5, 7, 10, 14, 21, 28, 56.

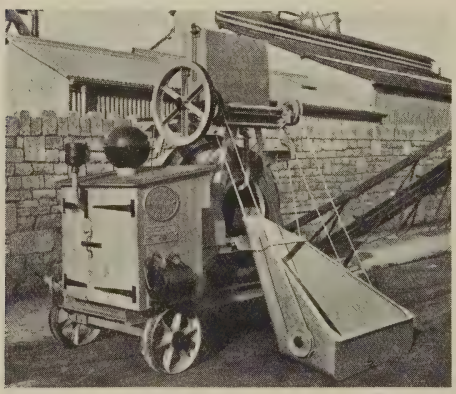


No. 5. Tilting Victoria Mixer, mainly for road work.

The chief feature about the Victoria Mixer is the ample capacity of the drum and its entire freedom from the little irritating troubles due to frail workmanship.

Every Victoria Mixer drum is built of sufficient thickness to withstand very rough usage and an ample margin of strength is allowed in those parts which are subjected to the greatest wear.

On the other hand, the weight is kept down to the lowest extent possible, so that the machines are handy and portable in operation.



No. 7. Victoria Mixer, for general concrete mixing.

In addition to their standard concrete mixers, Messrs. Stothert & Pitt manufacture all types of special Harbour-making concrete mixing plants. A large number of these have been supplied for use in Blockyards and Dockside Work, so that Messrs. Stothert & Pitt are in a position to offer a suitable plant for any possible requirements for producing mixed concrete of the right consistency.

STOTHERT & PITT, LTD.

MIXER DEPT. BATH

The illustration at the foot of this page shows a large chuting plant supplied by Messrs. Stothert & Pitt for building the Abertillery Water Board Dam. It will be noticed that two towers are provided each having its own chutes, jib and skips. This plant was the means of saving a tremendous amount of labour in placing concrete in position. Messrs. Stothert & Pitt manufacture these chuting plants in standard sizes to meet all requirements and they also supply a modified form of chuting plant known as the mast hoist for conditions where the chuting can be supported at regular intervals.

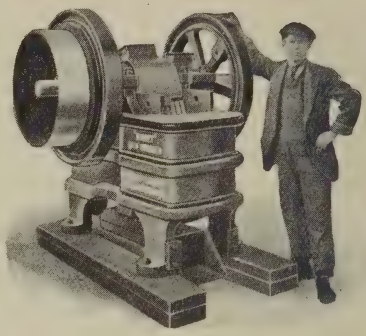
WINGET LIMITED

WINGET HOUSE GROSVENOR GARDENS WESTMINSTER, S.W.1

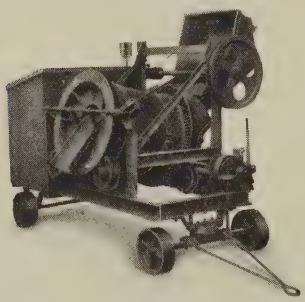
"WINGET" has become a household word in connection with modern constructional methods, not only through the world-wide reputation of its concrete machinery, but also because of the unequalled service and experience placed at the disposal of the ever-increasing "Winget" public. "Winget" organization has been a synonym for efficiency since its foundation in 1906.

As the pioneer system, it has grappled with all the problems of modern building and done more than anything or anyone to popularize concrete construction on common-sense lines.

Winget Limited, make all kinds of concrete plant besides their well-known block machines. Stone breakers and clinker crushing rolls of the most powerful and efficient type are supplied for dealing with aggregate of any description. The crusher now illustrated is supplied in three sizes, with 8 × 5 in., 10 × 7 in., and 12 × 8 in. jaw mouth. Supplied either as a separate unit or with engine complete—easy to move and ready to start work at once.



One of the "Winget" Crushers.



The 4 cu. ft. Semi-Spiral Wet Concrete Mixer.

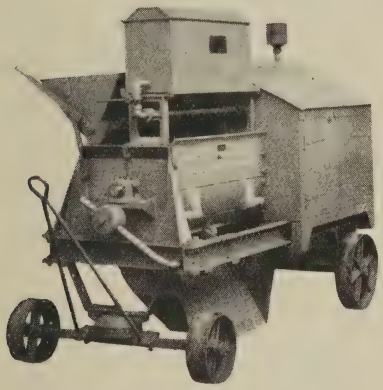
The "Warwick" 2½ cu. ft. Wet Concrete Mixer.

For mixing either wet or semi-wet concrete Winget Limited have a range of machines to fit the needs and pockets of every builder and contractor. For wet mixing the "Winget" Semi-Spiral Machine, in sizes ranging from 4 cu. ft. to ¾ cu. yd. capacity, produces a better mix in a shorter time than can be obtained by any other method. The mixing process is a gentle, continual, and scientific pouring together of the whole of the ingredients. Perfect proportioning with this machine is ensured by the elevating hopper.

The "Warwick" 2½ cu. ft. Wet Concrete Mixer is light, easy to run, and pays for itself in a few weeks. It is admittedly the handiest little mixer on the market, and produced at a price which brings it within reach of every builder and contractor.

WINGET LIMITED

WINGET HOUSE GROSVENOR GARDENS WESTMINSTER, S.W.1



The No. 2 "Winget" 4 cu. ft. Chain-Spade Mixer for semi-wet concrete.

THE No. 2 "Winget" 4 cu. ft. Chain-Spade Mixer, specially designed for concrete as used in the manufacture of blocks and slabs for building purposes, has long since made its reputation as the best semi-wet mixer the world has ever produced. Can be driven by benzole or petrol engine, electric motor or belt.

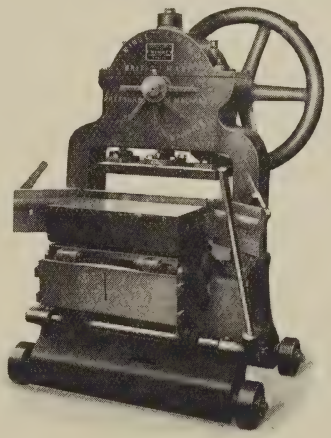
Winget's famous Standard 32" Block and Slab-making Machine (hand-tamped) makes not only every kind of concrete block and slab for building purposes, including quoins, copings, floor-tiles and bricks, but also concrete pipes, kerbs, gate piers, etc.

The "Winget" Pressure Machine has been specially designed for the rapid production of concrete blocks for the erection of cottages and small buildings. It is manufactured in two types, for hand, or power. The automatic power type, which develops a greater pressure than any other machine of its kind and produces the finest blocks and slabs, curbs, heads and sills, etc., is the very last word in scientific block making.

Two smaller concrete block machines are made by Winget Limited. One of these is the "Westminster," which manufactures blocks 18" × 9" × 4½", or 18" × 9" slabs, 2", 2½", and 3" thick, as well as half-blocks and half-slabs, made two at a time. Wooden pallets may be used if desired, as well as cast-iron pallets. Accessories are also supplied for making concrete bricks on this machine—frogged or plain. The other machine referred to is a cheaper edition of the "Westminster," known as the "Warwick," designed for the production of blocks and slabs only.

Among other outfits supplied are the "WINGET" Roofing Tile Machine, which solves the roofing problem for all types of buildings; and a wide range of "WINGET" Portable Conveyors, capable of handling all kinds of aggregate and other material up to 70 tons an hour.

Foundry and Engineering Works: The Cape, Warwick.



"Winget" Pressure Machine—Hand Power Type.

WHITSON & CO.

104, WEST GEORGE STREET. GLASGOW

Sole Agents.

CENTERING,

AND

MOULD OIL,

"LEAF" BRAND.

The result of long, scientific and practical experiments.

—

No Sticking.

—

No Hammering.

—

No Delay Setting.

—

No Damage to Concrete.

Perfect Finished Surface.

—

Waterproofing Effect.

—

Does not dry.

—

Preserves Wood.

—

Prevents Iron Rusting.

—

Satisfaction guaranteed.

—

Prices on application.

—

Telegrams:

"Whitson, Glasgow."

TOCH BROS.

NEW YORK LONDON TORONTO

THE R.I.W. PROTECTIVE PRODUCTS CO., LTD.

74 Vicarage Lane, London, E.15.

Telephone : Maryland 1589.
Telegrams : "Cemenflor, Strat, London."
Branch Offices : Liverpool, Glasgow, Dublin, Swansea, Brighton

R.I.W. CEMENT FILLER is a transparent coating for brush application to dry concrete floors to prevent cement dusting.

R.I.W. CEMENT ENAMEL is applied as a finishing coat where protection and decoration are required. It is proof against oil, grease and water. Made in fourteen standard shades. Special shades to order. CEMENT FILLER AND CEMENT ENAMEL is used on many of the leading hotels, flats, houses and office buildings, also in all classes of factories where cleanliness is necessary.

R.I.W. LIQUID "KONKERIT" AND LIQUID "KONKERIT" PRIMER.

Liquid "Konkerit" Primer neutralizes lime inherent in cement, stucco or concrete, and gives a proper foundation for finishing coat.

LIQUID KONKERIT (a flat paint): This is a finishing cement paint ready for use, for damp-proofing, beautifying and overcoming the natural porosity of stucco, concrete, and masonry walls; also used on interior walls and ceilings where a flat finish is required. Made in white, natural and colours.

R.I.W. "KONKERIT KOATING" (a dry powder): For application to a wet or damp surface of concrete or stucco. Combines with the surface and forms a hard non-dusting, light reflecting finish.

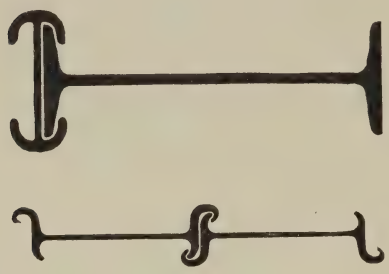
In grades for interior and exterior use. White and natural and can be tinted with any of the cement colours to required shade.

(*See also pp.* 224, 309 & 310.)

TOCH BROTHERS

BRITISH STEEL PILING COMPANY

DOCK HOUSE BILLITER STREET LONDON, E.C.3



STEEL SHEET PILING

The Universal Joist
43 lbs. per square foot.

The 12-in. Simplex
26.5 lbs. per foot run.

The 8-in. Simplex
22 lbs. per square foot.

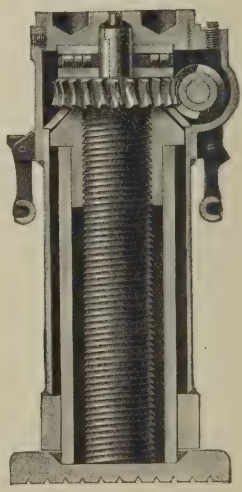
The ZENITH MIXERS—Output batch capacity ½ cu. yd. to 2 cu. yd.—for the quick handling of big batches.

TILTING-DRUM MIXERS—Output batch 3 cu. ft. to 7 cu. ft.—A cheap reliable machine that with care you'll never wear out.

THE ATLAS JACK.

SIZES
15
25
35
50
75
100
TONS

The Lightest Jack for its capacity. It will withstand 3 times its rated capacity on head and twice capacity on toe before fracturing.



BRITISH STEEL PILING COMPANY

DOCK HOUSE BILLITER STREET LONDON, E.C.3

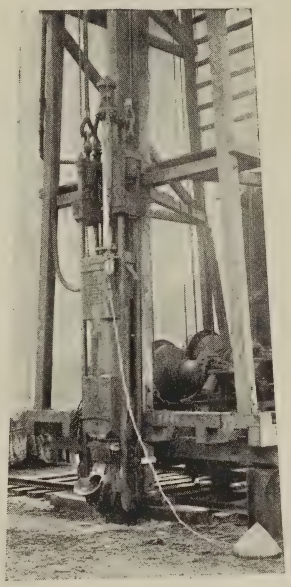
THE ZENITH VIBRO CONCRETE PILING PLANT

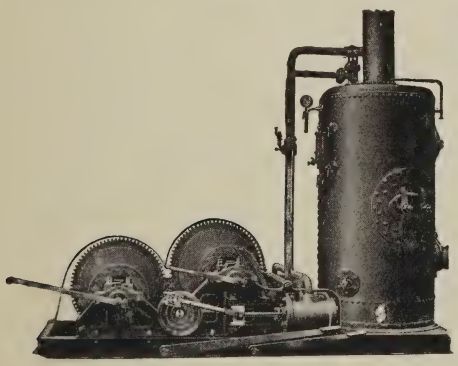
The most up-to-date equipment for the construction of cast in situ foundation piles—resulting in piles of sound structural value, accuracy in ascertaining driving resistance and rigid economy.

The use of this equipment makes the construction of foundation piles

A SCIENTIFIC PROCESS.

Hire Rates and Licenses for the plants arranged upon request.





THE ZENITH WINCH

Steam, Petrol or Electric Drive.

STEAM SHOVELS.

Write for full range of Bulletins.

CONCRETE PILING, LTD.
68-69, WINDSOR HOUSE VICTORIA STREET, S.W.1

PILING.

We are
SPECIALISTS
in all kinds
of
Piling Work
for
PIERS,
WHARVES,
JETTIES,
DOCKS,
SLIPWAYS
and
EVERY KIND
of
FOUNDATION
CONSTRUCTION.

We are prepared
to quote keen prices
for all classes of
PILE-DRIVING,
" MONOLITH,"
PRE-MOULDED
CONCRETE,
TIMBER
AND
STEEL SHEET
PILES.

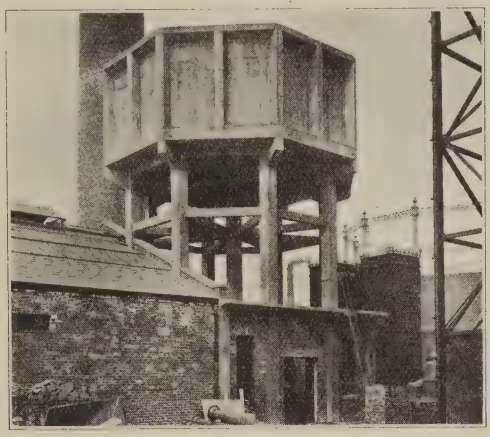
—

Telegrams :
" Pilkrete, Sowest,
London."
Telephone :
Victoria 4934.

SIMPLEX CONCRETE PILES, LTD.

104, VICTORIA STREET LONDON, S.W.1

Telephone : Victoria 541. *Telegrams :* "Simpilesco, Sowest, London."



Water Tower Constructed by us on "Simplex" Piles.

SIMPLEX
CONCRETE PILES

PILE FOUNDATIONS
and
REINFORCED CONCRETE
STRUCTURES
of all descriptions.

Our method of constructing and driving Simplex Concrete Piles at one operation obviates weeks of delay in commencing and completing work.

Works : EDMONTON.
10, COOK STREET, GLASGOW.
31, BOLD STREET, WARRINGTON.

Write for Illustrated Booklet.

J. & W. STEWART

12, BERKELEY STREET LONDON, W.1

A form for every pile.
A pile for every purpose.

RAYMOND CONCRETE PILES.

Use the Raymond System.

The pile consists of practically solid steel collapsible core, over which is drawn a sheet shell, spirally reinforced on the inside with steel wire, and closed at the point with a steel boot. A steam hammer drives the encased core to the required depth, after which the core is collapsed and withdrawn as shown, leaving the shell in the ground. After inspection by passing a light down, the steel shell is filled with concrete. The shell prevents distortion by earth pressure, ensures a perfect pile, and stops water in the ground from entering the concrete. No blow is delivered on the concrete, and the piles are cast in the ground in the steel shell to the exact length required.

Full particulars on request.

Est. 1874.

Also at Belfast and Dublin.
Mayfair 306–8.
" Cymplecks, Piccy, London."

Specialists in Piling & Reinforced Concrete.

Sole licensees for the Raymond System. Original sole licensees for the Simplex Pile. The most up-to-date Piling Contractors in the United Kingdom.

BEDFORDSHIRE TILE CO., LIMITED

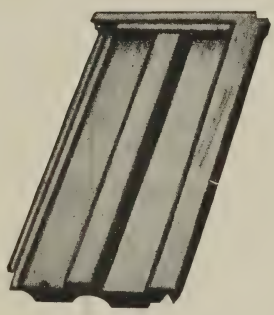
GROVEBURY WORKS — LEIGHTON BUZZARD, BEDS.

With Siding to L. & N.W. Ry.

THE COMPANY PRODUCES CONCRETE ROOFING TILES, BOTH INTERLOCKING (140 to the square) AND OF THE WELL-KNOWN BROSELEY PATTERN AND SIZE.

Both are made from the same materials, combining the superior excellence of the renowned LEIGHTON BUZZARD SAND with a SPECIAL STANDARD OF CEMENT to give exceptional strength, imperviousness, and durability. THE INTERLOCKING TILE HAS THE ADVANTAGE OF LIGHTNESS (7 cwt. per square as compared with 12 cwt. in the case of clay tiles), SPEEDY AND EASY FIXING, MODERATE COST, AND A CONSIDERABLE SAVING OF TIMBER, BESIDES DISPENSING WITH BOARDING, FELTING AND NAILS.

Produced plain or Sand-faced, and in a variety of permanent colours, that present a WARM, PLEASING AND NON-MECHANICAL APPEARANCE WITH PERFECT UNIFORMITY IN FIXING.



The "Bedfordshire" Tile.

Frost resisting with freedom from lamination.

THE CHEAPEST AND MOST EFFECTUAL FORM OF ROOF COVERING IN THE MARKET.

Broseley Pattern Tiles.

BRADSHAW'S REINFORCED CONCRETE CO., LTD.

87, WINDSOR HOUSE VICTORIA STREET LONDON, S.W.1

ENGINEERS,
DESIGNERS,
and CONSTRUCTORS
of Power-driven Machines for the Mass Production of Concrete and Reinforced Concrete Goods.

SPECIALISTS
in the Mass Production of small units in Concrete and Reinforced Concrete by Power-driven Machines.

The mass production of **Steel Reinforcements** for small units **electrically welded.**

REPETITION
work in Wood Moulds.

We aim at making Concrete and Reinforced Concrete Goods on or **as near to the site where they will be used** as possible.

Where this can be carried out it means a **great saving to the customer,** by
REDUCTION IN FIRST COST,
NO FREIGHT CHARGES,
THE ELIMINATION OF BREAKAGES.

Write to us, tell us what you want made in quantities, and **name the Place of Delivery.** We will then quote you.

OUR WORKS are exceptionally well placed to deal with Orders from all parts being situated on the **Main Arteries of the Midlands,** with
RAIL
ROAD and
CANAL FACILITIES.

May we Quote you for
FENCE
and
GATE POSTS,
PAVING SLABS,
PIT PROPS
and
BEAMS,
CONCRETE PIPES,
ELECTRIC CABLE
CONNECTING BOXES,
or anything else you need?

BRADSHAW'S REINFORCED CONCRETE CO., LTD.

87, WINDSOR HOUSE VICTORIA STREET LONDON, S.W.1

Bradshaw's Patent "Boom" Type Posts are essentially **Scientifically designed Monolithic structures** carried out on sound Engineering principles and which can be made to suit any Requirement or Test.

They are **stronger** than any other practical design of the same sectional area.

They are considerably **lighter** than other designs of the same strength because all unnecessary material has been eliminated from the design. The dead weight of the useless neutral axis area does not exist in our "Boom" Type.

They possess a very important property not usually attributed to concrete structures, i.e. **Flexibility.**

At an Official Test we were able to produce a **deflection of more than 1″ to 1 lin. ft. of Post** out of ground, without the slightest sign of failure (see illustration) and they will stand a **long series of Repetition Bending Stresses** being applied in quick succession at a speed of 20 deflections per minute.

Is there another Reinforced Concrete Post which will stand these Tests?

In **weight** they are approximately that of Timber.

In **Price**, generally speaking, they are about the same.

They have **a good appearance.**

Therefore we can offer you a post with all the qualities of Steel, with the weight and flexibility of Timber, at a most economical price, **because our posts will outlast them all.**

OUR DESIGNS INCLUDE:—

Telegraph and **Telephone** Posts.

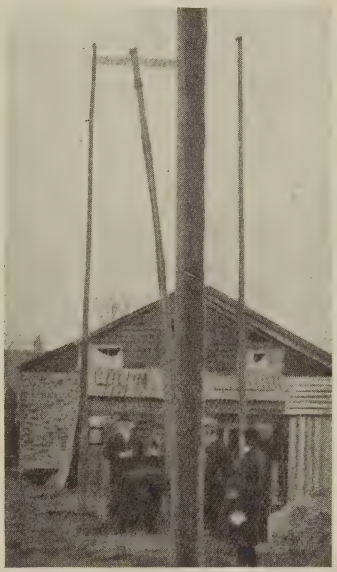
Supports for Overhead Cable Transmission Electric Power and Light Schemes. In Ordinary, "A," or "H" Patterns.

Standards for Electric and Gas Lamps, Promenade Lights, etc.

Tramway Poles to suit British, Indian, United States or any other Standards.

Pit Props and Beams to suit all conditions of settlement and "creep" and which will give warning before the "crush" becomes dangerous.

Write for the particulars of our **Special Free Service Offer.**



One of our 30 ft. Telegraph Poles being Tested to 1096 lbs. (67 per cent. overload). Deflection measured 27″.

BRISTOL CONCRETE CO., LTD.

BACKWELL NEAR BRISTOL

In order that buyers may be certain of securing concrete products of first-class quality, made of the best materials, we have registered the Trade Mark

BICRETE

for all our products, which include :—

ARCHITECTURAL STONEWORK in natural finish or colour.

GARDEN ARCHITECTURE in weathered finish.

TUBES AND CULVERTS.

KERBS AND CHANNELS.

FENCING POSTS.

GATE PIERS.

DIRECTION POSTS.

TANKS AND TROUGHS.

We shall be pleased to quote for special designs on receipt of particulars.

Telephone :

Flax Bourton, 47.

CONCRETE UTILITIES BUREAU

35, GREAT ST. HELENS LONDON, E.C.3

If you require information on the manufacture or uses of

CONCRETE PRODUCTS,

you are invited to communicate with the

Concrete Utilities Bureau,
35, Great St. Helens,
London, E.C.3.

Telephone : Avenue 5422.

Any of the following pamphlets will be sent, free of charge, to those interested :—

Concrete Floors, Feeding Floors and Footpaths.

Concrete Poultry Houses and Piggeries.

Concrete Farm-buildings.

Concrete Troughs and Wells.

Concrete Greenhouses, Hot-beds, and Root-cellers.

Concrete in the Home.

Concrete Blocks : How to Make and Use Them.

Concrete : General.

Concrete : Its Artistic Possibilities.

Concrete Roads Specification.

Concrete : A Unique Building Material.

Concrete : How it is Made.

Concrete Tanks and Cisterns.

Concrete Paths and Pavements, Kerbs and Gutters.

Concrete Fences, Gate-posts and Walls.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

All interested in the development of, and new uses for, concretes, are invited to write us when they wish to buy or sell, to prove or test, to operate or exploit new Patents, Methods, Materials, Processes, Machines or Equipment, etc.

We have a wide Technical connection, and can offer unbiassed advice and prompt, active service in regard to the smaller propositions such as :—

Cement and Concrete Novelties.

Arranging exploitation and working of useful Home and Foreign Patents.

Criticism of improvements to existing processes, plant, etc., for Concrete, etc.

Utilization of waste products from Mills, Quarries, Works, etc.

Our policy is fair treatment, our charges are sometimes nothing but always moderate.

Our experience, and that of our wide technical and corresponding circle is at your disposal at all times when your aim is more and better Concrete.

If you are a Concrete producer, write us at any time, when you wish to learn of the latest Concrete Novelities, Patents, etc., that might possibly prove good lines for you.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

SPECIALIZE
IN
UNCOMMON
CONCRETE
PRODUCTS,
SUCH AS:

STUCCO SLABS
ON
WALLBOARD
OR
CONCRETE.

—

ARTIFICIAL
MARBLE SLABS
(POLISHED).

STREET NAME
PLATES.

—

COLOURED
CEMENT LETTERS
AND SIGNS.

—

FIGURES
(STATUARY,
GROTESQUES,
ETC.).

—

IN FANCY
COLOURS,
SHAPES, ETC.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

SPECIALIZE
IN THE
PRODUCTION
OF
ARTIFICAL STONE
PRODUCTS
TO
SPECIAL DESIGNS
ONLY.

—

INTRICATE
OR ARTISTIC
PATTERNS.

—

NEW COLOURS
AND SHAPES.

METHODS
DEVELOPED.

—

DIFFICULTIES
OVERCOME.

—

DESIGNS
MODELLED.

—

MOULDS AND
APPARATUS
SUPPLIED
AND EXCHANGED.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

UNCOMMON CONCRETE PRODUCTS.

REINFORCED CONCRETE SAFES.

All believers in concrete should keep their valuables in the new Reinforced Concrete Safe, made in various sizes and qualities, for Homes, Offices, Banks, etc.

These are stronger and much cheaper than the All-Steel Safe—more fireproof—burglar-proof and fall-proof.

Send for further particulars, illustrations, prices, etc.

If you are disposed to take on the manufacture of the Concrete parts under license for an exclusive district, we have an interesting proposition to make to you.

CONCRETE INDUSTRIES, LIMITED

SOUTHAMPTON HOUSE 317, HIGH HOLBORN, W.C.1

Telephone : Holborn 1875.

This Company has been formed to promote the adoption of concrete for general constructive purposes. The Company offers its services to manufacturers and others in the designing, production, sale and distribution of all descriptions of concrete goods, including the selection and adaptation of suitable machinery and plant, supervision of manufacture, etc., etc.

The Company's works at "Broomleaf," Farnham, Surrey, will combine general research work with the production of all kinds of building requisites—as well as samples of every description—under experienced technical direction, and the Company being in affiliation with the Concrete Supply and Marketing Co., Ltd. (*noted on p.* 287), of which it is the Founder, will be mutually interested with other producers in the disposal of goods to common advantage.

Works : Broomleaf, Farnham, Surrey.

CONCRETE SUPPLY & MARKETING CO., LTD.

66, VICTORIA STREET LONDON, S.W.

Telephone : Victoria 8960.
Telegrams : "Consupmar, Sowest," London.

This Company has been formed to provide for Manufacturers of Concrete goods a ready and effectual means of placing their products on the market with the aid of comprehensive Catalogues descriptive of all kinds of concrete material in conjunction with an organized system of canvass embracing all classes of customers, and whereby introductions may be effected and manufacturers given a free hand in the conduct of their businesses without further interference by the Company or its agencies.

By means of a Classified Register orders will be apportioned and localized to the best economical advantage.

The universal character of the canvass should provide an incentive to the best results as compared with isolated efforts in the interest of individual producers of one class of goods only and thereby give to every producer an effectual agency for the disposal of his products.

The Company's charges will be limited to an agreed commission on sales effected.

Manufacturers are invited to submit particulars of their goods with designs for insertion in the catalogue.

CONCRETE MANUFACTURERS (NO. 1 LONDON), LTD.

BRIMSDOWN MIDDLESEX

Telephone : Enfield 682.

Makers of anything worth making in CAST CONCRETE and ARTIFICIAL STONE.

We design, or carry out designs, for any possible form of Concrete or Artificial Stone unit.

We design and advise for any reinforced concrete construction, but do not construct other than units made at our Works.

We make any form of required concrete blockwork, but specialise and recommend the proved two-block walling system, making these from plain rough concrete, for surfacing after building, to the highest grade imitations of natural stone.

OUR ARTIFICIAL STONE IS AS MUCH LIKE STONE AS ARTIFICIAL ICE IS LIKE ICE.

Our *ART STONE* (note the abbreviation) does not pretend to imitate stone ; it is better than most free and lime stones, and may be obtained in any permanent tint and to any texture.

We have established what is probably the most scientific and up-to-date Concrete unit works in the Kingdom, in which the whole of our manufactures are made and cured under the most favourable conditions from absolutely the best and cleanest material. The Concrete used is scientifically correct as to mix and moisture ; the finished product the best that can be produced.

CONCRETE MANUFACTURERS (NO. 1 LONDON), LTD.

BRIMSDOWN MIDDLESEX

Telephone : Enfield 682.

Our Staff includes an Artist in Concrete, an Architect, and Engineer fully conversant with its possibilities.

With the ⊤ SYSTEM we take off from the plans, prepare and supply details from which we manufacture exactly for the job. All members requiring reinforcement are adequately designed and manufactured accordingly.

For the HOUSE we include everything possible in concrete, walls, flooring, walling and roofing tiles, steps, hearths, sills, lintels, chimney stacks, caps and pots.

For the GARDEN everything from the crazy path, borders, etc., to cast and cut inspirations in what might be new or antiquated stone.

For the FARM and the ESTATE, walling and tiling of all kinds, bins, posts, pens, piggeries, portable stack piles and flooring, silos, tanks, troughs, etc., etc.

For the WAREHOUSE, HALL, FACTORY, or similar building the Marques Patent Reinforced System which saves all shuttering and finishing costs.

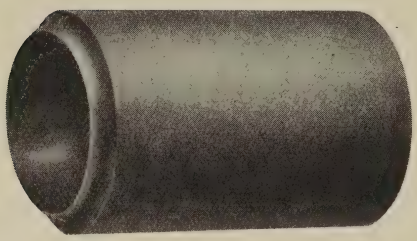
WE INVITE ENQUIRY AND INSPECTION.

ARCHITECTS will find we have an artistic sense of their conceptions. ENGINEERS will discover the exactness of our methods.

Write, or 'Phone (Enfield 682). Our Managing Director, MR. CHAS. MARQUES, will give each enquiry his personal attention.

THE CRAIG-LELO QUARRY CO., LTD.

GWYDDELWERN near CORWEN N. WALES



This Company is now in a position to accept orders in any quantities for its products.

All concrete goods are made from our own granite aggregates and best heavy Portland cement only is used, every care being taken to supply a first class article.

The road stone and chippings are cubically broken and well graded.

The Tarviated granite supplies a long felt want, and will be found thoroughly reliable.

Telephone : Corwen 23.
Telegrams : Lilo, Gwyddelwern.

CONCRETE GOODS.
REINFORCED TUBES.
FENCING POSTS.
PAVING FLAGS.
CURBS.
CHANNELS.
BUILDING BLOCKS, and
EVERY DESCRIPTION OF
PRE-CAST CONCRETE.

ROAD STONE IN
ALL SIZES FROM
2½ in. to DUST.

GRANITE COATED
WITH TARVIA "A."

THE PATENT "LELO"
RUBBER-FACED
CONCRETE PAVING.

Applications for particulars of the Patent Lelo Paving should be made direct to the Manager.
Mr. C. D. POCHIN.

EVANS BROS.

RIDDINGS ALFRETON DERBYSHIRE

Telephone : RIDDINGS 3.
Telegrams : "EVANS BROS., RIDDINGS."

ARTIFICIAL STONE AND CAST CONCRETE PRODUCTS.

ACTUAL MANUFACTURERS OF ALL CLASSES OF PRE-CAST CONCRETE, A DEFINITE GUARANTEE BEING GIVEN WITH EVERY ARTICLE SOLD.

AIRBRICKS, COPINGS, DOOR HOODS, RIDGE TILES, SILLS, STEPS and ARTIFICIAL STONE FACINGS OF EVERY DESCRIPTION.

STREET KERBING, CHANNEL, GUARD RAILING, FENCE POSTS and COMPLETE FENCING (WITH OR WITHOUT ERECTION), POSTS FOR WOOD RAIL and CLOSE BOARD FENCING.

GARDEN FRAMES, GARDEN EDGING, FEEDING and DRINKING TROUGHS, TANKS, ETC.

Write for illustrated circulars :—
FOR FENCING : *Circular F.*
FOR CONTRACTORS' GOODS : *Circular B.*
FOR AGRICULTURAL SECTION : *Circular A.*

REINFORCED CONCRETE ENGINEERS AND CONTRACTORS.

DESIGNS PREPARED OR CONTRACTS CARRIED OUT FOR ANY CLASS OF REINFORCED CONCRETE CONSTRUCTION.

TANKS OR RESERVOIRS FOR ALL PURPOSES GUARANTEED WATER-TIGHT UP TO 50 FT. HEAD OF WATER.

WHEN CARRYING OUT A CONTRACT THE DESIGNING DEPT. KEEPS IN THE CLOSEST TOUCH WITH THE ACTUAL WORK AS IT PROCEEDS.

Works carried out include :—

Covered Reservoir : 350,000 gals. capacity, for Butterley Co., Ltd.

Service Reservoir : 50,000 gals., for Chesterfield R.D.C.

Elevated Service Reservoir : 50 ft. high. 45,000 gals., at Rolleston Hall.

Water Softening Tanks at Bromboro' Port, Doncaster and Sheffield.

Stone Bunkers at Ambergate for the Derbyshire County Council.

Slack Bunkers for the United Steel Companies, Ltd.

Conference Hall (The Hayes).

Domed Roof for the Derbyshire Education Committee at Ilkeston.

Telpher House at Sheffield Gas Works.

Machine Gallery at Sheffield for Messrs. Vickers, Ltd.

Bridge and Culvert, Chesterfield.

Retaining Wall at Staveley.

Flat Watertight Roofs for the Derbyshire County Education Committee.

GLOUCESTER CONCRETE CONSTRUCTION CO., LTD.

HEMPSTEAD GLOUCESTER

FERROSHIP BRAND.
ARTIFICIAL STONEWORK.

Our products are
SCIENTIFICALLY
MANUFACTURED BY
SPECIAL MACHINERY.
They compare very favourably
with natural stone in
FINISH,
DURABILITY
and
COST.

We quote for any class of
ARCHITECTURAL
DRESSING,
in large or small quantities.

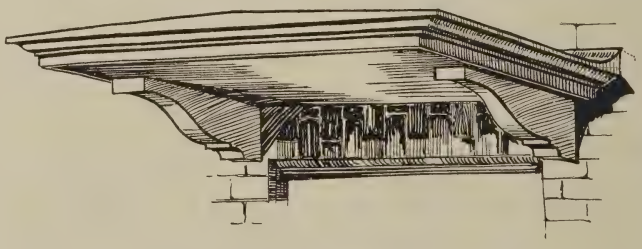
WE STOCK
Lintels,
Sills,
Door Hoods,
Balusters,
Coping,
Cornice Jambs, etc., etc.

FOR FARM AND ESTATE
WORK we recommend our
Posts, Cattle Troughs, and
other similar specialities.

We hold WELL MATURED
stocks of
Paving Slabs,
Kerb,
Channel, etc.,
as well as BREEZE AND
CONCRETE BLOCKS.

Enquiries invited.

Telegrams : " Ferroship."
Telephone : Gloucester 984.



Sketch of Door Head.

H. LILL

CEMENT STONE WORKS SKEGNESS LINCOLNSHIRE

Every description of
CEMENT STONE
PRODUCTS
Manufactured in natural grey or colours.

SPECIALITIES:
Mullions and Jambs for Steel Windows, entirely eliminating the slender appearance of Steel Windows and saves a wood frame surround.

Pilaster Blocks for stiffening Light Concrete Walls.

Concrete Pipes,
Posts, Troughs,
Channels,
Paving Flags,
Kerbs, Beams,
Sills, Heads,
Strings, Arches, Etc.
IN GREY OR COLOURS

Telephone: No. 115.
Telegrams:
"Lill, Skegness, 115."

A line of Concrete Pipes supplied to the Skegness U.D.C. for their Sewer Extension.

LINDUM STONE CO.

CANWICK ROAD LINCOLN

Portion of Balustrade Terrace, Wall, Vases, Steps, etc., recently executed by us for C. C. Sibthorp, Esq., Sudbrooke Hall, near Lincoln.

Cornices,
Moulded String-Courses,
Door and Window Heads,
Cills,
Modelled Panels,
Steps, Landings,
Balustrades, Gate Piers,
Domes,
Tracery Windows,
Capitals, Copings, Date Stones,
Columns, Fountains, Finials, &c.,
And every stonework requisite.
Solid throughout, combined with
BEST WORKMANSHIP AND
GUARANTEED DURABILITY

GARDEN ORNAMENT

of every description
Flower Vases,
Urns,
Ornamental Flower Boxes,
Garden Seats,
Fountains,
Figures,
Pedestals, etc.

TENDERS

Given on Architects' Designs, Samples of Masonry sent free, Photographs from the Clay Models supplied for Approval before reproduction in concrete.

LINDUM STONE CO.

CANWICK ROAD LINCOLN

THREE-QUARTERS
OF A CENTURY'S EXPERIENCE
IN THE MANUFACTURE
OF
"IMPERISHABLE"
("Castle Brand")
ARCHITECTURAL
CONCRETE MASONRY
FOR
DRESSINGS.

Among the advantages which our stone-work possesses over ordinary Stone, the following may be emphasised :—

It is more durable, yet less expensive. It is perfect fitting with even lines. A natural granulated stone-like surface to any degree.

A SPECIALITY

Is made of Tracery Windows and Every Style of Ecclesiastical Dressings, etc.

H. SYKES, ESQ., M.S.A., DROGHEDA, *Architect.*

Tracery Windows and Door Tympanium recently executed by us for Methodist Church, Drogheda.

CONCRETE UTILITIES BUREAU

35, GREAT ST. HELENS LONDON, E.C.3

At 143, Grosvenor Road, London, S.W.1, a permanent Exhibition of Concrete Products has been installed which includes, among others, exhibits in connection with

BUILDINGS :—

Architrave
Asbestos and Cement Tiles and Sheets
Building Blocks
Carved and Moulded Panels
Chalk Concrete Blocks and Bricks
Door Head and Threshold
Food Locker
Ornamental Panels
Panelling and Tracery
Roofing Tiles
Steps
Surfaces of various colours and texture
Walls
Window Heads and Sills

ESTATE, FARM AND HOME :—

Balustrading
Carved Bust
Cowstalls
Fencing Posts
Garden Frame
Gate Posts
Mangers
Pergola
Pigstyes
Poultry Houses
Rail Fencing
Stable Paving
Steps
Tanks and Troughs with Moulds
Vases and Pedestals
Walls
Well Tubes
Window Box

PUBLIC AUTHORITIES :—

Cast letters for Street Name Plates
Culverts
Direction Posts
Electrical Feeder Cable Post
Flower Vase for War Memorials
Gully
Headstones
Hydrant Box
Inspection Chambers
Kerbing and Channelling
Lamp Posts
Notice Board Posts
Paving Slabs
Piles
Road (Section)
Septic Tank
Sewer Manhole
Sewer Pipes
Syphon for Road Drainage
Tree Guard

RAILWAYS :—

Bridge Number Plates
Culvert Blocks
Gate Posts
Gradient Posts
Mile Posts
Platform Section (complete)
Roller Blocks
Signal Post
Signal Wire Post
Sleepers
Switch Post
Telegraph Pole
and many articles mentioned under the other headings.

All who are interested in the use of concrete are cordially invited to visit this collection.

LIVERPOOL ARTIFICIAL STONE CO., LTD.

PICTON ROAD WAVERTREE LIVERPOOL

TELEPHONE: WAVERTREE 1030.

TELEGRAMS: "BRESLABS, L'POOL"
SIDINGS: WAVERTREE STATION, C.L.C.

PURE WHITE CONCRETE SPECIALISTS.

ARTIFICIAL STONE CAST ACCURATELY

TO DETAIL AND DRESSED BY HAND TO MATCH THE COLOUR AND TEXTURE OF ANY NATURAL STONE.

SPECIALITIES

MADE TO ORDER AT SHORT NOTICE. STEPS, HEADS, SILLS, LINTOLS, COPING, CORNICE, LANDINGS, FLOOR SLABS, PIER CAPS, STRING COURSE, COLUMNS, BASES AND CAPS, ASHLAR, CANOPIES, MULLIONS, REINFORCED BEAMS, ELECTRIC CABLE COVERS, FENCE AND GATE POSTS, KERBS AND CHANNELS, BREEZE FIXING BRICKS, STEP LINERS, ETC.

REGISTERED OFFICE:
B22, THE TEMPLE,
DALE STREET, LIVERPOOL.

MANUFACTURERS OF EVERY DESCRIPTION OF PRE-CAST CONCRETE.

GRANITE CONCRETE PAVING FLAGS

STANDARD SIZES 3′–0″ × 2′–0″, 2′–6″ × 2′–0″, 2′–0″ × 2′–0″, 1′–6″ × 2′–0″ × 2″, 2½″, AND 3″.

COKE BREEZE CONCRETE PARTITION SLABS

3′–0″ × 1′–0″ × 2″, 2½″, 3″ AND 4″.

KEYED ALL EDGES.
ALWAYS IN STOCK.

MANUFACTURED FROM PURE WASHED COKE BREEZE.

SPECIALLY GRADED PENMAENMAWR GRANITE.

EARLE'S "PELICAN" CEMENT.

DELIVERIES BY RAIL OR SEA.
ENQUIRIES INVITED.
SAMPLES AND PRICES ON APPLICATION.

REDHILL TILE COMPANY, LIMITED

"KINGSFIELD" REDHILL SURREY

Telephone : Redhill 473.

The high standard of excellence attained by this Company's "REDHILL" CONCRETE INTERLOCKING ROOFING TILE gives it first rank as a very efficient form of Roof Covering.

Made by skilled workmen of long experience with carefully selected materials of the highest grade under expert Supervision.

The "REDHILL" Tile combines the following features :—

Exceptional strength and permanence.

Pleasing non-mechanical appearance.

Resistance to Frost and Rain.

Freedom from lamination.

Warmth in Winter and Coolness in Summer.

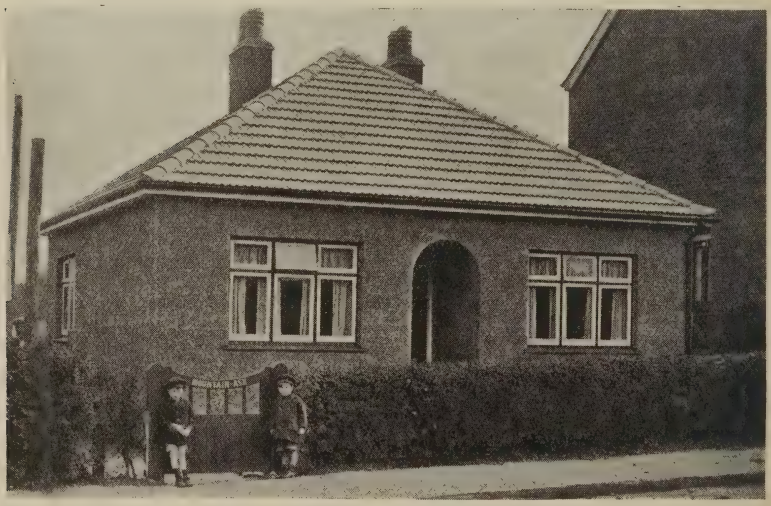
Lightness (7 cwt. of 156 tiles per square).

Simple and expeditious fixing without Nails, Boarding or Felting.

A considerable saving (25 per cent.) in Battens (the maximum gauge being 12 in.).

Produced in a variety of Colours, Plain, Blended, Sand-faced, etc.

CHEAPNESS.



Bungalow Roofed with "Redhill" Tiles

REDHILL TILE COMPANY, LIMITED

"KINGSFIELD" REDHILL SURREY

The "REDHILL" TILE is made to a specification approved by the Ministry of Health after Official Inspection of the Works, and its use by Housing Authorities has been specially authorised without any guarantee as insisted on in other cases.

Lending itself to all forms of construction and offering resistance to Acids and Corrosion, a demand has arisen for the "REDHILL" TILE by several Gas Companies, including the largest in the London area, where it is being used with every satisfaction.

Prices are quoted Free on Rail or Lorry at the Redhill Works, or to include delivery and fixing by the Company's experienced Tilers where desired.

The "Redhill" Tile.

The great demand for the "REDHILL" TILE having necessitated a considerable extension of the Works and Plant (with Railway Siding) the Company is also producing Fencing Posts to the Specification of the Southern Railway and other Customers, besides a variety of other Concrete Goods, including—

Partition Slabs,
Floor and Edging Tiles,
Heads and Sills,
Steps, etc.

Prompt delivery from matured stocks.

Further particulars with illustrations, testimonials and Visit from representative on request.

Telephone :
Redhill 473.

TRENT CONCRETE, LIMITED

COLWICK NR. NOTTINGHAM

Telephone :
Carlton 62.

Telegrams :
" Concrete, Netherfield."

AGGREGATE FOR CONCRETE.

REINFORCING BARS.

REINFORCING FABRIC.

Artificial Stone of any description.

Fence Posts, Lintols,
Kerb, Steps,
Coping, Heads,
Sills, Paving Slabs,
Breeze Partition Slabs, etc.

CRUSHED GRAVEL AND WASHED SAND.

We have completed a reinforced concrete crushing and washing mill, with bunker capacity for 5,000 tons. This mill can produce the finest Crushed Trent Gravel and Washed Sand, as used on some of the largest concrete work in England.

Delivery.—We can guarantee big deliveries up to 1,000 tons per day, and can load immediately on receipt of order.

THE WHARF LANE CONCRETE CO., LTD.

ILMINSTER SOMERSET

Stone Screen recently made by us to match Stonework of House.

MAKERS OF

The finest Fence for Road Improvements, also of the Somerset County Council Fence.

Concrete Pipes (specially strong section with flat base).

Clinker and Breeze Slabs, Fixing Bricks, Breeze Joists, Tiles.

Concrete Fencing and Gate Posts.

Cowstall Feeding Troughs and Stall Divisions.

Piggery Fittings.

Drinking Troughs—plain or with valve box.

Well Linings and Septic Tanks.

Experts say that we are far and away ahead of any other Maker of Artificial Stone.

Ask us to quote you for Copings, Balustrades or Panels for Bridges.

We can make all the Stonework for a dwelling house, viz. Doorways, Mullioned Windows, Chimneys, Copings and Gable Finials, Gate, Piers, etc., etc.

All can be made to match your local stone.

Telephone: Ilminster 36.

BRUNNER, MOND & CO., LIMITED

NORTHWICH CHESHIRE

Telephone : No. 1.
Telegrams : "CRESCENT."

LONDON SALES OFFICE :
7 Cavendish Square, W.1.
Telephone : Langham 2820, 2821.
Telegrams : "Sesqui, Wesdo, London."

SILICATE OF SODA FOR CONCRETE TREATMENT.

Special Brands for—
HARDENING CONCRETE ROADS, BUILDING BLOCKS AND PAVING STONES.
DUSTPROOFING CONCRETE FLOORS.
WATERPROOFING CONCRETE TANKS.
OILPROOFING CONCRETE TANKS, GARAGE FLOORS, ETC.

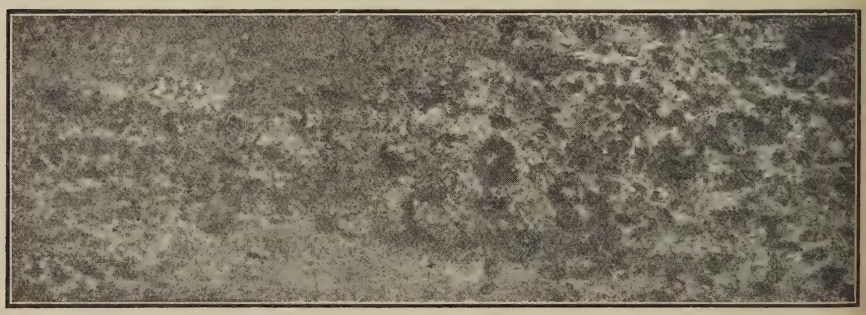
SILICATE OF SODA treatment is inexpensive and easily carried out.

Prolonged trials have shown that the life of concrete roads can be materially increased by a suitable treatment of Silicate of Soda, and abrasion and dusting can be prevented.

SILICATE OF SODA treatment fills up the pores near the surface of the concrete, renders it less pervious and so prevents liquids entering the concrete when it is put into use.

Oil, sewage and other materials, if allowed to soak into concrete, cause disintegration. When concrete has set properly it is impervious, but Silicate of Soda treatment enables oil tanks, garage floors, etc., to be put into use with safety much sooner than would be the case with an untreated tank or floor.

SEND FOR ILLUSTRATED LITERATURE.



Concrete Road after six months' heavy traffic. The surface on the left was previously treated with our special Silicate of Soda. Much less abrasion has taken place on this portion of the road than on the portion shown to the right of the photograph where the road was not treated.

BRUNNER, MOND & CO., LIMITED

NORTHWICH CHESHIRE

Telephone: No. 1.
Telegrams: "CRESCENT."

LONDON SALES OFFICE:
7 Cavendish Square, W.1.
Telephone: Langham 2820, 2821.
Telegrams: "Sesqui, Wesdo, London."

CALCIUM CHLORIDE FOR CONCRETE TREATMENT.

Until a few years ago two methods of curing concrete were usually employed:—

(1) Curing under water.

(2) Curing with moist earth or sand.

When these methods are used on a concrete road, the latter must be closed to traffic for three or four weeks and the cost of handling water is often considerable.

A concrete road can be cured with atmospheric moisture by the use of our POWDERED CALCIUM CHLORIDE. This is spread on the concrete at the rate of $2\frac{1}{2}$ lb. per square yard as soon as the initial setting has taken place. Such treatment will keep the concrete surface continuously wet.

CALCIUM CHLORIDE added to concrete when gauging accelerates the setting considerably.

The table below gives some results obtained by the New York State Highways Department, and shows how, after seven days, the strength of concrete containing CALCIUM CHLORIDE becomes as high as that exhibited by plain concrete after twenty-one days.

CEMENT WASHES.

The water used for making up cement washes should contain 4 per cent. of CALCIUM CHLORIDE. Such a solution is made up by adding 1 lb. of our POWDERED CALCIUM CHLORIDE to three gallons of water. The presence of CALCIUM CHLORIDE keeps the wash coat damp for several days and enables the cement to set properly.

Age in Days.	Compression strength in lbs. per sq. in.	
	Plain Cement.	2.12 lbs. $CaCl_2$ per sack Cement.
7	1,700	3,200
14	2,850	4,000
21	3,150	4,200
28	3,450	4,400

BUILDING PRODUCTS LIMITED

64, COLUMBIA HOUSE 44-46, KING'S ROAD SLOANE SQ., S.W.3

WATERPROOFING MATERIALS.

BAREAU—Cement Concrete Waterproofing Powder.

The use of this powder form waterproof is specially recommended where concrete mixers are used. Bareau is absolutely certain in its waterproofing qualities. It does not weaken cement, on the contrary it makes it slightly stronger in compression.

PRUFIT—Cement Concrete Waterproofing Paste.

Prufit is prepared in the form of a rich creamy paste and mixes readily with the gauging water, which is the medium by which it is distributed. It is carried uniformly to every part of the concrete, and on account of its absolutely foolproof action is strongly recommended for use where the concrete mixing is done by hand.

PRUFITOL—Liquid Surface Weatherproofer.

For making existing structures of stonework, brick, or stucco proof against rain and atmospheric damp. Prufitol lines the pores of brickwork and other absorptive materials with a water repellent substance, keeping out all rain and dampness, but allowing air to pass freely. It is not a filler which shuts out air and flakes off with the first frost. It is a transparent solution and does not alter the appearance of the surface treated.

HARDENING MATERIALS.

FERROLITHIC—Concrete Floor Hardener.

For proofing concrete floors, tanks, reservoirs, etc. There is no dusting, crumbling, or " patchiness " where Ferrolithic is used. A Ferrolithic floor is as hard as cast iron, and everlasting. It is *the* floor for garages, workshops, and factories, etc.

AQUALITHIC—A Liquid Treatment for Dusty Floors.

Aqualithic renders brick, stone, and concrete floors dustless, waterproof and oilproof. It is sprinkled on the floor and brushed gently over the surface, allowing the concrete to absorb it freely. Two coats are necessary. The treatment lasts about four or five years.

CORUNDITE—A natural aluminous abrasive of special use for producing a nonslip paving surface.

SPECIAL NOTE.

BUILDING PRODUCTS LIMITED

are not satisfied with the mere sale and supply of their specialities. They are willing and anxious to serve their customers' best interests, and are prepared to investigate fully any proposition involving the use of their products so that they may be employed to the greatest advantage of the user.

Write for full particulars of the products which interest you.

THE BUXTON LIME FIRMS CO., LTD.

BUXTON DERBYSHIRE

"LIMBUX"
THE IDEAL HYDRATED LIME FOR CONCRETE WORK.

"LIMBUX" is prepared from specially picked Buxton lime by a careful process of mechanical slaking and testing. It is put on the market in the form of a uniform white powder. Its addition to concrete renders the latter more plastic and its lubricating properties enable chuting operations to be carried out with less water than usual without any fear of the formation of stone pockets.

It renders concrete more dense and more waterproof.

The beneficial effect of HYDRATED LIME upon the strength of concrete is not fully realized. When tests are made with specimens taken from batches of concrete as used in road construction it has been shown that the compression strength is materially increased by the use of HYDRATED LIME. The figures given below were obtained by the Delaware State Highway Department and are of unusual interest because they give a true indication of the actual strength of the concrete under working conditions.

Lime slaked on the job will not give the same uniform results as "LIMBUX" because of the unavoidable formation of lumps when lime is slaked by hand and not properly tested.

Telephone : 312 Buxton.

Telegrams : "Buxton Lime, Buxton."

COMPRESSIVE STRENGTH.

Percentages of Hydrated Lime based upon the weight of Portland Cement in the mixture.

0 per cent. Lime lbs. per sq. in.	2½ per cent. Lime lbs. per sq. in.	5 per cent. Lime lbs. per sq. in.	7½ per cent. Lime lbs. per sq. in.
3,108	2,908	3,596	3,514
2,203	3,640	4,381	5,092
2,529	3,476	3,473	4,498
2,613 Avg.	3,341 Avg.	3,816 Avg.	4,368 Avg.

CEMENT INDUSTRIES

SIDDALS ROAD WORKS DERBY

CHEMICALS AND COMPOUNDS

for

Curing,

Waterproofing,

Bonding,

Hardening,

Acid-proofing,

Cleaning down,

Polishing,

Accelerating,

Coating, etc.,

of Concretes, Mortars, etc., supplied in bulk quantities only, at the day's lowest market prices.

Including :—

Fats, Lime Soaps and Emulsions,
Bitumen and Tar Preparations,
Silicates (Soda, etc.),
Barium (Hydrate, Sulphate, etc.),
Fluoride Compounds,
Earths, Clays and Minerals,
Polishing and Abrasive Materials,
Quick Setting and Hydrated Lime,
Hot and Hydraulic Lime,
Lime Accelerators,
Calcium Chloride,
Acids (Hydrochloric, etc.),
Plaster retarders, etc., etc.

Write for particulars, naming quantities required, etc. Samples, prices, instructions and information on the uses of these and other materials furnished on request.

C. A. PETERS, LTD.

STORES ROAD WORKS — DERBY

Telegrams :
"Peters, Derby."

Telephone : Derby, 399.

Produce and market at fair prices for the Concrete and Building industries :—

(1) CEMENT WATER-PROOFING POWDER (packed in 20 lb. galvanized buckets).

(2) FLUATE CRYSTALS for hardening and rejuvenating Concrete work (packed in 120 lb. and larger barrels).

(3) Other CHEMICAL SPECIALTIES for these industries.

Write us for particulars and prices of anything you may need in this line.

SLATE INDUSTRIES, LIMITED

COETMOR YARD BETHESDA NORTH WALES

"MYRTOX"
(Registered) an Inert
Filler.

The New Silicious
Compounding Powder.

Supersedes BARYTES,
WHITING, KIESEL-
GUHR, etc.

Constant Composition.
High Acid and Weather
Resistance.
Absolute Accuracy of
Grading.
(From 20 to 300 Mesh.)

Fine and Velvety in Texture for—
Acid and Weather Resisting
Paints and Distempers.
Mechanical and Moulded Rubber Goods.
Polishes of all kinds,
Unequalled for Mortar,
Rough Casting, Plaster,
and

Fine for—
Cleansers,
Asphalt Road Making,
Flooring,
Disinfectants,
Proofing Mixtures,
Bricks, Blocks and Tiles,
Concrete Mixtures,
Insulating Purposes,
Dusting Powders.

Fine in Price and Fine in Quality.
For Samples and Prices apply to
the Original Manufacturers and
Pioneers of the Utilization of
Slate Waste for Manufacturing
Purposes.

Telegrams: "Slate Industries,
Bethesda."

TOCH BROTHERS

NEW YORK LONDON TORONTO

THE R.I.W. PROTECTIVE PRODUCTS, CO., LTD.

74, Vicarage Lane, London, E.15
Telephone : Maryland 1589
Telegrams : "Cemenflor. Strat. London."
Branch Offices : Liverpool, Glasgow, Dublin, Swansea, Brighton.

No. 421, R.I.W. ACID-PROOF TOXEMENT :

This is a special grade of R.I.W. Toxement, usually used in conjunction with R.I.W. Acid-Proof Filler, for Acid-Proofing and Water-Proofing concrete storage tanks in which oils or acids solutions are stored, bins, floors, walls, foundations and other concrete surfaces.

R.I.W. ACID-PROOF FILLER :

This material is a complex solution of silicates, and its function is to precipitate silica, and other materials in colloid form in the pores of the concrete, and also to act as a binder where concrete is inclined to crumble. It is based on one of the newer ideas of using solution which can be applied to a concrete surface that is wet or damp, but it makes no difference if the surface be dry and dusty.

R.I.W. FLINTOX (CRYSTALS) :

For chemically hardening and dust-proofing concrete floors. May be applied to wet or damp floors. Its function is to precipitate silicious materials in the pores of the cement or concrete, and acts as a binder and hardener.

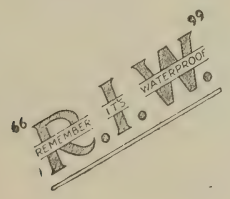
R.I.W. SELF-HEALING BRIDGE CEMENT :

A waterproof non-hardening, coherent and adherent material which is applied over burlap. Maintains an unbroken membrane coating under normal conditions. Largely used for bridges, floors, and protecting foundations subject to severe conditions and corrosive agencies.

R.I.W. CONCRETE PLASTER BOND :

A black waterproof, elastic, tacky material which is applied to the insides of exterior concrete walls. Plaster adheres firmly to same and it also prevents efflorescence penetrating and damaging the decorations.

(*See also pp.* 224, 271 *and* 310.)



TOCH BROTHERS

TOCH BROTHERS

NEW YORK LONDON TORONTO

THE R.I.W. PROTECTIVE PRODUCTS CO., LTD.,
74, VICARAGE LANE, LONDON, E.15
Telephone : Maryland 1589.
Telegrams : " Cemenflor, Strat, London."
Branch Offices : Liverpool, Glasgow, Dublin, Swansea, Brighton.

R.I.W. TOXEMENT CEMENT WATER-PROOFING COMPOUND used for water-proofing concrete in floors, walls, bridges, foundations, piers, reservoirs, etc.

It is a known and accepted fact that the penetration of water will cause concrete to crack and disintegrate, also the reinforcement to rust. R.I.W. TOXEMENT added to the mixture fills the pores, and water-proofs the concrete. It lubricates the concrete, causing it to settle in a denser mass, thereby allowing a smaller ratio of water.

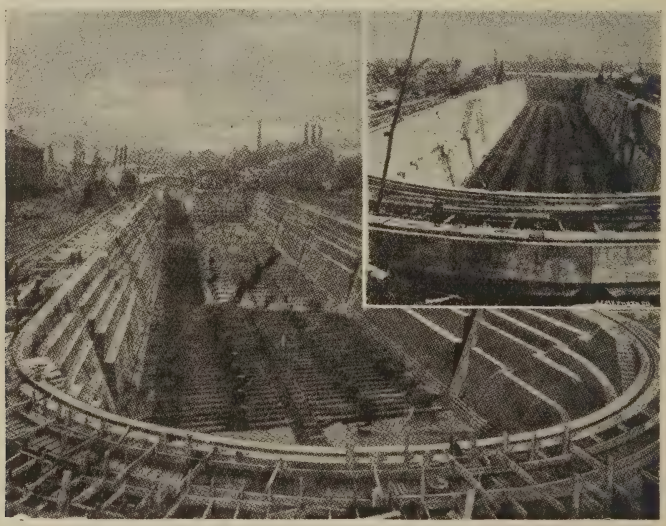
TOXEMENTED CEMENT CONCRETE, when placed by means of chutes, flows more readily and is placed more easily in the forms.

R.I.W. TOXEMENT is used by the leading Government departments throughout the world on account of its reliability.

Manufacturers of all classes of protective material, whether used indoors or outdoors, as part of a building, factory, dock, etc., exposed to wear, the elements, dampness, chemical fumes, or electrolysis, demands proper protection with a different type of paint or compound.

All enquiries are dealt with in a technical and practical manner by a qualified concrete engineer and chemist.

See also pages 224, 271 and 309.



New York Dry Dock No. 4 (length 703 ft. ; width at top, 130 ft. ; depth from coping to bottom, 42 ft.).

TORBAY & DART PAINT CO., LTD.

26-28, BILLITER STREET LONDON, E.C.3

CONCRETE
SWIMMING BATHS,
PADDLING POOLS,
BOATING LAKES, AND
RESERVOIRS
can be made
WATERTIGHT WITHOUT
THE EXPENSE OF RENDER-
ING BY THE ADDITION OF
"NOVOID" TO THE
CEMENT.

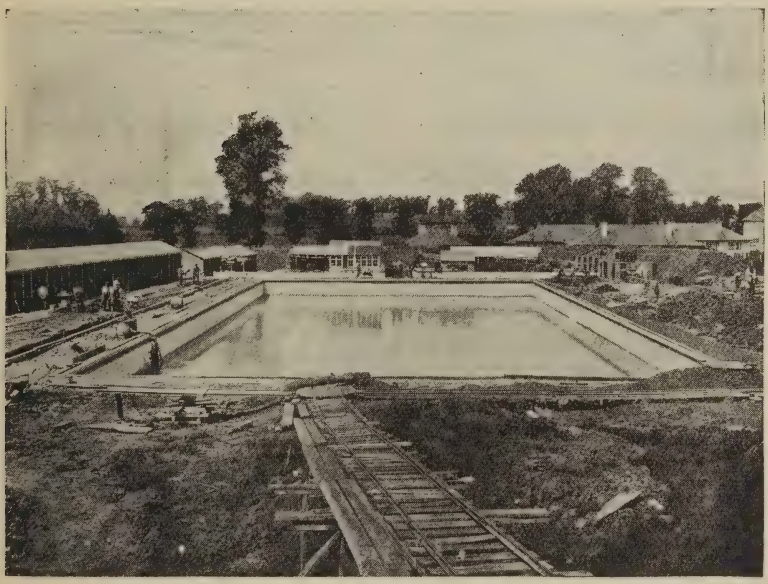
Specify and Use

NOVOID
THE CONCRETE PROOFER
REGISTERED TRADE MARK

ENTIRELY SUPERSEDES
ALL MECHANICAL
WATERPROOFERS.

NOVOIDED CONCRETE
FLOORS and ROADS are as
DURABLE AS GRANITE.

HARROW-ON-THE-HILL U.D.C. OPEN-AIR SWIMMING BATH.



Engineer and Surveyor : J. Percy Bennetts, Esq. Contractor : Harry Neal, Esq., Northwood.

Novoid used in the Mass Concrete on the Walls and Floor.
Proportions 1 : 2 : 4 with 7% Novoid.

CONCRETE UTILITIES BUREAU

35, GREAT ST. HELENS LONDON, E.C.3

THE CONCRETE UTILITIES BUREAU is an organization formed for the purpose of rendering assistance, *free of charge*, to those in need of information or advice on the subject of concrete.

In order to afford every possible assistance to engineers and others who are considering the possibilities of concrete for road work, the Bureau has opened a special

ROADS DEPARTMENT

in charge of engineers who have had actual experience in reinforced concrete road construction. The services of these experts are placed at the disposal of surveyors and others interested in this subject.

The Bureau has also set up an

INVESTIGATION DEPARTMENT

and will advise as to the suitability and use of aggregates submitted for examination.

This department will be pleased to test any materials which are to be used in conjunction with concrete, and investigate the possibilities of any new uses for which concrete may be employed.

BROWN & TAWSE, LTD.

3, LONDON WALL BUILDINGS LONDON, E.C.2

Messrs. De Witts' Factory, Croydon, London.
FLOORS REINFORCED WITH B & T SQUARE MESH.

B & T FABRIC

is especially suitable for

road foundations,

floors, walls,

swimming baths,

etc., etc.

B & T Twisted Bars

made in sizes

from $\frac{3}{16}$ in. to $1\frac{1}{2}$ in. sq.

B & T FABRIC

is made in flat sheets to any required size and in weight from 2 lb. to 18 lb. per sq. yd.

BROWN & TAWSE, LTD.

R.C.M. Dept. *Tele.:* London Wall 6240.

3 London Wall Bldgs., London, E.C.2.

EXPANDED METAL CO., LIMITED

YORK MANSION PETTY FRANCE LONDON, S.W.1

Works: West Hartlepool.
Established over 30 years.

PATENTEES AND MANUFACTURERS OF EXPANDED METAL.

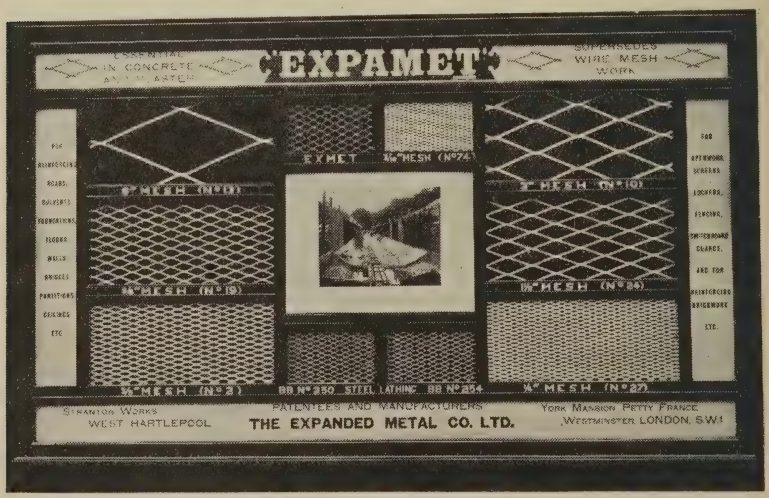
"EXPAMET" EXPANDED STEEL is manufactured from blank mild steel sheets and plates; it is machine-made, of meshwork formation, and has no joins, no welds and no loose or separate strands or attachments: the junctions between the meshes remain uncut, and all the strands or members in a sheet are connected rigidly and have continuous fibres—important features peculiar to Expanded Metal. The finished product is itself evidence that the material from which it is made is free from flaws and defects; otherwise, in the expanding, any fault in the blank would cause fracture of the strands: the process of manufacture is, therefore, a thorough test of the quality of the steel.

"EXPAMET" EXPANDED STEEL has been in successful and ever-increasing use all over the world for more than 30 years past.

The illustration shows the various meshes in which "EXPAMET" EXPANDED STEEL is manufactured.

As reinforcement for concrete it has exceptional qualities, especially in large plain and curved areas. It is particularly suitable for use in roads, foundations, walls, floors, roofs, lintels, arches, bridges, grain silos, coal pockets, tanks, reservoirs, dams, retaining walls, piers, abutments, pipes, sewers, conduits, etc.

"EXPAMET" EXPANDED STEEL of the 3 in. mesh weights is used mostly for such work, and the 1½ in. and 6 in. meshes also may be used in some cases; the lighter weights of the ¾ in. and 1½ in. meshes are used in concrete for encasing steelwork, and 6 in. mesh weights in concrete roadways, pavings, tramway tracks and the like.



EXPANDED METAL CO., LIMITED

YORK MANSION PETTY FRANCE LONDON, S.W.1

Works: West Hartlepool.
Established over 30 years.

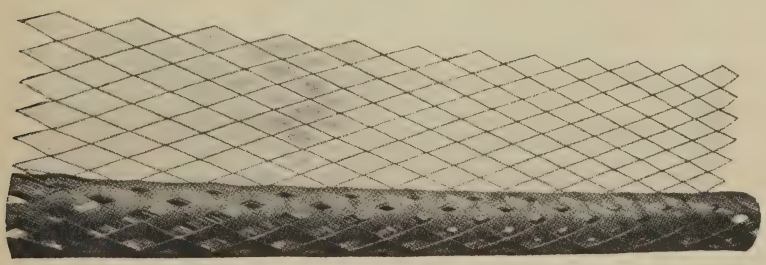
PATENTEES AND MANUFACTURERS OF EXPANDED METAL.

The continued progress of reinforced concrete in road work indicates that shortly it will occupy the premier position of all types of construction, where provision has to be made for speed of mechanically propelled vehicles, excessive modern weights and large volumes of traffic.

"EXPAMET" EXPANDED STEEL has been used from the inception: as early as 1905, Mr. W. E. Lowe, the U.D.C. Engineer and Surveyor, employed it to reinforce foundations over gas and water main trenches, encountered during the construction of the Pontypridd Tramways, and ten years later he reported that it had proved quite satisfactory.

Reinforced concrete is recommended by leading authorities on Road Construction, especially for roads carrying heavy traffic; a very material saving in concrete results from the use of reinforcement and, consequently, in excavations and in dead-weight on the ground; provision is made against local soft pockets and unequal settlement: and the cost of maintenance is low.

R.R. 6 in. mesh "EXPAMET" EXPANDED STEEL is a specially suitable reinforcement for concrete roadways, pavings, tramway tracks, and the like; it is made in sheets of any length, longway of mesh, up to and including 16 ft., by any width shortway of mesh up to and including 64 ft. according to the weight required; the wider sheets are supplied in rolls of small diameter and the narrower in bundles of flat sheets.



A Roll of R.R. 6 in. Mesh "Expamet."

HELICAL BAR & ENGINEERING CO., LTD.
72-74, VICTORIA STREET LONDON, S.W.1

HELICAL

For
FERRO-CONCRETE.

—

HIGH ELASTIC
LIMIT.

—

CONTINUOUS
MECHANICAL
BOND.

THE MOST
ECONOMICAL
BAR FOR
REINFORCEMENT.

—

MANUFACTURED
FROM MILD
STEEL AND NOT
HIGH CARBON
STEEL.

—

Telephone :
Victoria {1940
1941

Telegrams :
" Helistelba,
Sowest,
London."

WIRE TIE CO.

SIDDALS ROAD DERBY

WIRE TIES AND TOOLS
FOR REINFORCED CONCRETE WORK,
BRICK AND BLOCK
WALL TIES
AND
CEMENT BAG TIES.

We offer the usual form of Wire Ties or Loops made in our own works here with the following advantages :—

(1) Greatly reduced prices.

(2) Free and ample supply of Tools.

(3) Free exchange of Tools when worn or broken.

(4) Full Patent Protection as our methods of manufacture are fully protected.

(5) Better and tidier methods of packing the ties.

Send for samples and prices, naming the quantities usually bought and enclosing your samples.

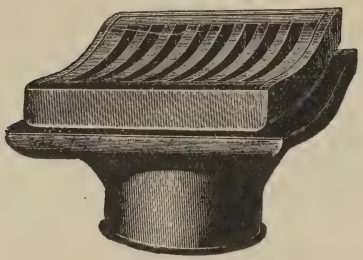
All Concrete Reinforcement firms and Cement Manufacturers should use them and save money, as well as many other industries in which their use could profitably supplant other methods.

To the very large buyers we are willing to rent the Patented Automatic Wire Tie-making Plant under agreement. Particulars furnished on request to users of (in or about) a million ties per month,

BURN BROTHERS (LONDON), LTD.

THE ROTUNDA 3, BLACKFRIARS ROAD LONDON, S.E.1

Serviceable Appliances for Ensuring a Watertight Joint to Concrete Asphalted Roadways, Roofs, or Floors.

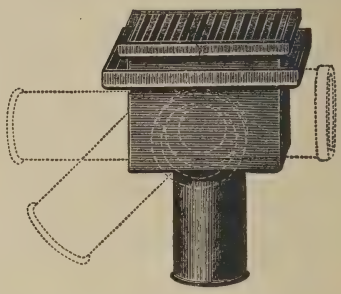


No. 189.—*Heavy Roadway Hinged Grating and Frame.*

12 × 9 in. inside to 9 in. diameter Bottom outlet for fitting over trap. Dished 1 in. deep for channel, with or without Luting Flange for Asphalte Paving.

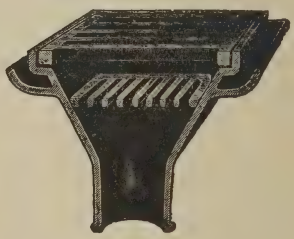
No. 198.—*Bent Gully Inlet with Luting Flange for Asphalte Paving.*

The Luting Flange in all cases locks the Asphalte and prevents leakage despite expansion and contraction.



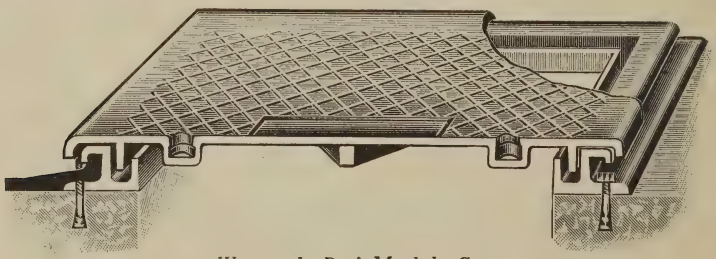
No. 119.—*Cast-Iron Cesspool and Grating.*

With Luting Flange, for Asphalte Flats.



No. 190.—*Gully Inlet and Double Gratings.*

With Luting Flange for Asphalte floor or Roof.



Water-tight Roof Manhole Covers.

THE SIDNEY TRADE ILLUSTRATIONS CO.

90-91, QUEEN STREET CHEAPSIDE LONDON, E.C.4

GENERAL COMMERCIAL ARTISTS, PHOTOGRAPHERS AND PROCESS ENGRAVERS.

We offer you the service of our Studios.

In return for your business we will give you satisfaction, which is what you require.

RETOUCHING for the ENGINEERING AND CONCRETE TRADE is our speciality.

DESIGNERS

Of Showcards, Posters, line and wash drawing.

HIGH GRADE

Photographic Enlargements for Exhibition purposes.

OUR PRICES

Are moderate in all branches of work.

We solicit your kind enquiries.

Our Phone Number is :—

CITY 6737.

CHAPMAN & HALL, LTD.

11, HENRIETTA STREET COVENT GARDEN LONDON, W.C.2

Detailed Prospectuses "C.Y." free on request.

CONCRETE: PLAIN AND REINFORCED.

By FREDERICK W. TAYLOR, D.Sc., and S. E. THOMPSON, M.Am.Soc.C.E.

Covers the entire subject, including processes, cement specifications, cement classifications, cement testing, proportioning, qualities of material, quantities of material, strength, mixing, laying, freezing, fire and rust protection, and waterproofing.

Third edition, revised and enlarged; 885 pages; 262 figures; many tables and diagrams. Price 30*s.* net.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION.

By F. E. TURNEAURE and R. E. MAURER.

Presents those principles in mechanics underlying the design of reinforced concrete. The results of all available tests that will aid in establishing coefficients in working stresses are given, and illustrative material from actual designs which will make clear the principles involved is also included.

485 pages; profusely illustrated. Price 20*s.* net.

PLAIN AND REINFORCED CONCRETE ARCHES.

By Prof. J. MELAN.

Gives a simple comprehensive treatment of stresses in reinforced concrete sections, and analytic and graphic methods for the complete design of all types of concrete arches.

161 pages; 43 figures and a folding plate. Price 12*s.* 6*d.* net.

THE THEORY AND DESIGN OF STRUCTURES.

By EWART S. ANDREWS, B.Sc., Eng. (Lond.).

Written so as to be sound as regards theory, and yet sufficiently practical and free from advanced mathematics to make it of use to the greater number of engineers and draughtsmen engaged in constructional work.

637 pages; illustrated; demy 8vo. Price 13*s.* 6*d.* net.

MATHEMATICS FOR ENGINEERS.

By W. N. ROSE, B.Sc., Eng. (Lond.).

Embraces all the mathematics needed by Engineers in their practice, and by students in all branches of Engineering.

Part I. Fourth edition; 520 pages; demy 8vo. Price 10*s.* 6*d.* net.

Part II. Second edition; 432 pages; demy 8vo. Price 13*s.* 6*d.* net.

CONCRETE WORK.

By W. K. HATT, C.E., Ph.D., and W. C. VOSS, B.S.

Deals extensively with the following subjects: Reading Blue Prints, Calculation of Quantities, Estimates of Cost, Selection and Inspection of Materials, Selection and Disposition of Equipment, Organisation of Gang, Staking Out, Excavating Form Work, Measuring, Mixing and Depositing Concrete and Protection of Work, etc.

Vol. I. 451 pages; 224 figures; 20 full-page plates. Price 23*s.* net.

Vol. II. 206 pages; 37 figures. Price 10*s.* net.

CHAPMAN & HALL, LTD.

11, HENRIETTA STREET COVENT GARDEN LONDON, W.C.2

Detailed Prospectuses "CY." Free on Request.

REINFORCED CONCRETE: A PRACTICAL HANDBOOK FOR USE IN DESIGN AND CONSTRUCTION.

By R. J. HARRINGTON HUDSON, B.Eng., A.M.I.C.E., A.M.I.Mech.E., M.C.I., M.Am.C.I.

With a foreword by E. FIANDER ETCHELLS, A.M.I.C.E., A.M.I.Mech.E., Hon. A.R.I.B.A., M.Soc.C.E. (France). Past-President of the Concrete Institute.

This Practical Handbook explains in a simple manner the theory of reinforced concrete and furnishes just those tables, charts, data and other items of information which are of the greatest practical value in designing and executing sound and economical reinforced concrete construction. It is intended for students and for others who are actually engaged in the design and construction of reinforced concrete work; engineers, architects, engineering and architectural draughtsmen, clerks of works, overseers, foremen and others. Every endeavour has been made to develop the practical side of the subject and present it in the simplest possible form.

The notation used throughout the book is the new Standard Notation of the Concrete Institute.

Demy 8vo; 342 pages; 131 figures; numerous tables and 10 folding plates. Includes valuable Tables and Charts for Office Use. Price 16*s.* net.

TABLES FOR REINFORCED CONCRETE FLOORS AND ROOFS.

By R. TRAVERS MORGAN, M.Eng., A.M.I.C.E., A.M.I.Mech.E., M.I.Struct.E.

(*In Preparation.*)

ARCHITECTS' & BUILDERS' POCKET BOOK.

By the late FRANK E. KIDDER, Ph.D., re-written by THOMAS NOLAN, and a Staff of specialists.

For Builders, Architects, Structural Engineers and Draughtsmen, containing information on every subject likely to come before them.

Seventeenth edition, re-written, nearly 2,000 pages. Profusely illustrated. Price 35*s.* net.

WATERPROOFING ENGINEERING.

By JOSEPH ROSS.

Will be found a valuable reference in the daily work of practising engineers, architects, and contractors. Past and present methods and materials of waterproofing are explained, their efficiency given, and helpful conclusions are drawn.

452 pages; 138 figures. Price 25*s.* net.

McGRAW-HILL PUBLISHING CO., LTD.

6, BOUVERIE STREET LONDON, E.C.4

We specialise in Concrete and Structural Books.

THE ONLY "STANDARD" BOOK.

CONCRETE ENGINEERS' HANDBOOK.

By G. A. HOOL and N. C. JOHNSON.

800 pages. 30*s.* net.

A compact reference book containing tables, formulæ and data on plain and reinforced concrete. It is up-to-date and covers the entire field thoroughly. It contains a wealth of valuable material which has been collected by a staff of specialists in different branches of concrete construction. In the presentation of material graphically, the choice of illustrations and the special flexible binding, the book is designed for efficient use on the desk and drafting table.

CONTENTS.—I.—Materials. II.—General Methods of Construction. III.—Construction Plant. IV.—Concrete Floors and Floor Surfaces, Sidewalks and Roadways. V.—Properties of Cement Mortar and Plain Concrete. VI.—General Properties of Reinforced Concrete. VII.—Beams and Slabs. VIII.—Columns. IX.—Bending and Direct Stress. X.—Moments in Rigid Building Frames. XI.—Buildings. XII.—Foundations. XIII.—Retaining Walls. XIV.—Slab and Girder Bridges. XV.—Concrete Floors and Abutments for Steel Bridges. XVI.—Arches. XVII.—Hydraulic Structures. XVIII.—Miscellaneous Structures. XIX.—Estimating. APPENDICES: A.—Standard Specifications and Tests for Portland Cement. B.—Working Stresses. C.—Rulings Pertaining to Flat-Slab Design. D.—Standard Notation.

"You *must* have it."

CONCRETE DESIGNERS MANUAL. (Tables and Diagrams for the Design of Reinforced Concrete Structures.) By G. A. HOOL and C. S. WHITNEY. 276 pages. Price 20*s.* net.

The tables and diagrams make possible the rapid designing of reinforced concrete structures. Text is limited to explanations of the tables and diagrams. Where necessary, specific examples of how to use them are given.

Particulars mailed free.

REINFORCED CONCRETE CONSTRUCTION. (in 3 Volumes), by G. A. HOOL.

VOLUME 1—FUNDAMENTAL PRINCIPLES.

254 pages. 12*s.* 6*d.* net.

CONTENTS—I.—Concrete. II.—Steel. III.—Concrete and Steel in Combination. IV.—Rectangular Beams. V.—Slabs, Cross Beams and Girders. VI.—Columns. VII.—Slab, Beam and Column Tables. VIII.—Slab, Beam and Column Diagrams. IX.—Bending and Direct Stress. Tables. Diagrams.

VOLUME 2—RETAINING WALLS AND BUILDINGS.

666 pages. 30*s.*

CONTENTS.—PART I.—Retaining Walls. Chapter I.—Theory of Stability. II.—Design. III.—Construction. PART II.—Buildings—Section I.—Design. IV.—Floors. V.—Type of Reinforcement VI.—Roofs. VII.—Columns. VIII.—Foundations. IX.—Walls and Partitions. X.—Stairs. XI.—Elevator Shafts. XII.—Provision for Contraction and Expansion. XIII.—Shear and Moment Considerations in Continuous Beams. XIV.—Eccentric Load Considerations in Columns. XV.—Wind Stresses. XVI.—Design of a Factory Building. XVII.—Example of a Building Design Including the Specifications. SECTION II.—Construction.—XVIII.—Materials. XIX.—Forms. XX.—Bending and Placing of Reinforcement. XXI.—Proportioning, Mixing and Placing of Concrete. XXII.—Finishing Concrete Surfaces. XXIII.—Waterproofing of Concrete. XXIV.—Construction Plant, by A. W. Ransome. SECTION III.—Estimating, by Leslie H. Allen. XXV.—Estimating Unit Casts. XXVI.—Estimating Quantities. XXVII.—Example of an Estimate for a Concrete Building.

McGRAW-HILL PUBLISHING CO., LTD.

6, BOUVERIE STREET LONDON, E.C.4

VOLUME 3—BRIDGES AND CULVERTS. 688 pages. 30*s.*

CONTENTS.—PART I.—Arch Bridge. Chapter I.—General Data. II.—Reflection of Curved Beams. III.—Analysis of the Symmetrical Arch by the Elastic Theory. IV.—Design of an Earth Filled Arch Bridge. V.—Use of Influence Lines in Arch Analysis. VI.—Unsymmetrical Arches. VII.—Arches with Elastic Piers. VIII.—Arch Analysis by the Method of the Ellipse of Elasticity. IX.—Details of Arch Bridges. X.—Construction of Arch Bridges. XI.—Three-Hinged Arches. XII.—Patents. XIII.—Typical Designs of the Various Types of Arch Bridges. PART II.—Slab and Girder Bridges. XIV.—Slab Bridges. XV.—Simple Girder Bridges. XVI.—Continuous Girder Bridges. XVII.—Cantilever Bridges. XVIII.—Reinforced Concrete in Steel Bridge Construction. PART III.—Culverts. XIX.—Factors in Culvert Design. XX.—Pipe Culverts. XXI.—Box Culverts. XXII.—Arch Culverts. PART IV.—Notes on Construction Plant. XXIII.—Handling Materials. XXIV.—Mixing. XXV.—Transporting of Concrete. PART V.—Notes on Estimating. XXVI.—Estimating Bridges. XXVII.—Estimating Culverts. PART VI.—Present Status of the Art. XXIX.—Main Features in Design. XXX.—Ornamentation. PART VII.—The Construction in Detail of Several Types of Concrete Bridges. XXXI.—Construction of the Yardley Bridge. XXXII.—Construction of the Tunkhannock Creek Viaduct. XXXIII.—Construction of Unit-Built Concrete Pile. XXXIV.—Construction of Concrete Slab Bridges for Track-Elevation Subways. XXXV.—Construction of the North Samuels Avenue Viaduct, Forth Worth, Texas. PART VIII.—European Concrete Bridges. XXXVI.—European vs. American Practice. XXXVII.—Hinges or Arched Concrete Bridges.

THE HOOL AND KINNE SERIES.

To be completed in six volumes. Three volumes now ready.

FOUNDATIONS, ABUTMENTS AND FOOTINGS. 413 pages. 20*s.* net.

Some of the topics covered are :—Tests to Determine Soil Conditions, Excavation Methods, Foundations in Wells or Pits, Cofferdams, Open Caissons, Pneumatic Caissons, Piles, Waterproofing of Substructures, Retaining Wall Foundations, Dam Foundations, Machinery Foundations, Ordinary Bridge Piers, Bascule Bridge Piers, Abutments.

STRUCTURAL MEMBERS AND CONNECTIONS. 611 pages. 30*s.* net.

This second volume covers the design of steel and cast-iron members, of wooden members, and of reinforced concrete members and splices and connections for steel members and for wooden members.

Some of this information has never before been available in book form.

CONTENTS—I.—General Theory. II.—Design of Steel and Cast-iron Members. III.—Splices and Connections for Steel Members. IV.—Design of Wooden Members. V.—Splices and Connections for Wooden Members. VI.—Design of Reinforced Concrete Members.

MOVABLE AND LONG-SPAN STEEL BRIDGES. 450 pages. 25*s.* net.

Special features are : the first complete treatment on the theory and design of Bascule bridges ; an especially thorough discussion of the theory and design of continuous and suspension bridges by D. B. Steinman ; new and short methods for determining stresses in swing bridges ; a comprehensive presentation of the theory and design of all types of arch bridges with detailed calculations for several large bridges now in service.

Authors of the above volumes are Prof. G. A. HOOL and Prof. W. S. KINNE, assisted by over 30 specialists.

May we send you full particulars?

McGRAW-HILL PUBLISHING CO., LTD.

6, BOUVERIE STREET LONDON, E.C.4

STANDARD BOOKS.

REINFORCED CONCRETE CONSTRUCTION.
By J. P. BROOKS. 200 pages. 10*s.*

CONCRETE CONSTRUCTION FOR RURAL COMMUNITIES.
By R. A. SEATON. 225 pages. 11*s.* 3*d.*

REINFORCED CONCRETE BUILDINGS. By E. L. RANSOME and A. SAURBREY. 235 pages. 12*s.* 6*d.*

CONCRETE STEEL CONSTRUCTION. By E. MORSCH. 368 pages. 25*s.*

REINFORCED CONCRETE.
By BUEL & HILL. 499 pages. 30*s.*

REINFORCED CONCRETE DESIGN TABLES.
By M. E. THOMAS and C. E. NICHOLS.
208 pages. 15*s.*

CONTENTS.—Notation and Formulæ. Explanation of Tables. Tables of Coefficients for Slabs and Simple Beams. Logarithmic Curves. Table of Bending Moments and Shear for Continuous Beams. Weights, Areas and Spacing of Bars. Weights of Concrete Members, in Pounds. Tables of Slabs and Single Beams. Tables of Tee Beams. Tables of Beams with Compression Reinforcement. Square Columns. Hooped Columns. Hooped Column Reinforcement. Vertical Column Reinforcement. Spacing and Percentages of Column Hooping. Table of Weights, Areas and Spacing of Bars.

ELEMENTS OF GRAPHIC STATICS
By CLARENCE W. HUDSON, Professor of Civil Engineering, Brooklyn Polytechnic Institute, and EDWARD J. SQUIRE, Assistant Professor of Civil Engineering, Brooklyn Polytechnic Institute. 91 pages, $5\frac{1}{2} \times 8$, fully illustrated. Price 6*s.* 3*d.* net, post paid.

The essentials of graphic statics, especially in their application to the calculations of re-actions, stresses, shears and moments. Only material actually necessary for a fundamental working knowledge of the subject is included. The book presents, however, a discussion of the special application of the subject to the investigation of the stability of arch rings and masonry dams.

CONTENTS.—I.—General Considerations. II.—Reactions. III.—Stresses in Simple Structures. IV.—Moment and Shear.

STRUCTURAL ENGINEERS' HANDBOOK.

Data for the Design and Construction of Steel Bridges and Buildings. Second Edition. 896 pages, 6×9, 400 illustrations, 250 pages, flexible binding. Price 30*s.*

The data, details, specifications and tables for the design and construction of steel bridges and buildings are presented in this book in compact, easily accessible form. It is a source book and encyclopædia of useful information that has hitherto been accessible only to a few engineers.

CONTENTS.—PART I.—DATA FOR DESIGN AND DETAILS OF CONSTRUCTION.—I.—Steel Roof Trusses and Mill Buildings. II.—Steel Office Buildings. III.—Steel Highway Bridges. IV.—Steel Railway Bridges. V.—Retaining Walls. VI.—Bridge Abutments and Piers. VII.—Timber Bridges and Trestles. VIII.—Steel Bins. IX.—Steel Grain Elevators. X.—Steel Head Frames and Coal Tipples. XI.—Steel Standpipes and Tanks on Towers. XII.—Structural Drafting. XIII.—Estimates of Structural Steel. XIV.—Erection of Structural Steel. XV.—Engineering Materials. XVI.—Structural Mechanics. XVII.—Design of Steel Details. PART II.—STRUCTURAL TABLES.—Properties of Plates.—Properties of I Beams. Properties of Channels. Properties of Angles. Properties of Miscellaneous Sections. Properties of Column Sections. Chord Sections. Details of Bars, Pins, etc. Details of Bolts and Rivets. Miscellaneous Structural Tables Bethlehem Sections.

McGRAW-HILL PUBLISHING CO., LTD.

6, BOUVERIE STREET LONDON, E.C.4

HANDBOOK OF BUILDING CONSTRUCTION.
GEORGE A. HOOL, Consulting Engineer; Professor of Structural Engineering, University of Wisconsin, and NATHAN C. JOHNSON, Consulting Engineer, assisted by a staff of forty-six specialists. Two Volumes, 1474 pages 6 × 9, flexible, fully illustrated, per set, £2 10*s*.

CONTENTS.—PART I.—Design and Construction—I.—Elements of Structural Theory. II.—Designing and Detailing of Structural Members and Connections. III.—Structural Data. IV.—General Designing Data. V.—Construction Methods. VI.—Construction Equipment. VII.—Building Materials. PART II.—Estimating and Contracting.—I.—Estimating Steel Buildings. II.—Estimating Concrete Buildings. III.—Architectural Practice. IV.—Contracts. V.—Specifications. PART III.—Mechanical and Electrical Equipment.—I.—Heating. Ventilation and Power. II.—Water Supply Data and Equipment. III.—Sewage Disposal. IV.—Waterless Toilet Conveniences. V.—Plumbing and Drainage. VI.—Electrical Equipment. VII.—Electric Lighting and Illumination. VIII.—Gas Lighting. IX.—Gas Fitting. X.—Elevators. XI.—Mechanical Refrigeration. XII.—Communicating Systems. XIII.—Lightning Protection. XIV.—Vacuum Cleaning Equipment.

STRUCTURAL ENGINEERING TABLES. E. GODFREY. Price 12*s*. 6*d*.
PROPERTIES OF STEEL SECTIONS J. C. SAMPLE. Price 15*s*.
GRAPHICAL ANALYSIS. W. S. WOLFE. Price 20*s*.
HANDBOOK OF STEEL ERECTION. M. C. BLAND. Price 12*s*. 6*d*.
DESIGN OF HIGHWAY BRIDGES OF STEEL, TIMBER AND CONCRETE. M. S. KETCHUM. Price 30*s*.
DESIGN OF STEEL BRIDGES. F. C. KUNZ. Price 30*s*.
BRIDGE AND STRUCTURAL DESIGN. W. C. THOMSON. Price 12*s* 6*d*.
DESIGN OF TYPICAL STEEL RAILWAY BRIDGES. W. C. THOMSON. Price 12*s*. 6*d*.
STEEL BRIDGE DESIGNING. M. B. WELLS. Price 12*s*. 6*d*.
THEORY OF ARCHES AND SUSPENSION BRIDGES. J. MELAN. 15*s*.
TYPES AND DETAILS OF BRIDGE CONSTRUCTION. F. W. SKINNER. Vol. 1. Price 15*s*. Vol. 2. 20*s*. Vol. 3. Price 15*s*.
DESIGN OF MINE STRUCTURES. S. M. KETCHUM. Price 25*s*.
DESIGN OF WALLS, BINS AND GRAIN ELEVATORS. S. M. KETCHUM. Price 25*s*.
DESIGN OF STEEL MILL BUILDINGS. S. M. KETCHUM. Price 30*s*.
PORTS AND TERMINAL FACILITIES. R. S MACEWLEE. Price 17*s*. 6*d*.
FRAMED STRUCTURES AND GIRDERS. E. MARBURG. Price 25*s*.
WHARVES AND PIERS. C. GREENE. 15*s*.
THEORY OF STRUCTURES. C. M. SPOFFORD. Price 25*s*.
DESIGNING AND DETAILING OF SIMPLE STEEL STRUCTURES. C. T. MORRIS. Price 12*s*. 6*d*.
DESIGN OF PLATE GIRDERS. L. E. MOORE. Price 15*s*.
KINETIC THEORY OF ENGINEERING STRUCTURES. D. A. MOLITOR. Price 25*s*.
STRUCTURAL ENGINEERING. J E. KIRKHAM. Price 25*s*.
FOUNDATIONS OF BRIDGES AND BUILDINGS. H. S. JACOBY and R. P. DAVIES. Price 30*s*.
A TEXTBOOK ON GRAPHIC STATICS. C. W. MALCOLM. Price 17*s*. 6*d*.
ELEMENTS OF STRUCTURES. G. A. HOOL. Price 8*s*. 9*d*.
TABLES OF STRESSES IN ROOF TRUSSES. H. C. HEARNE. Price 20*s*.

"CONCRETE ROADS"

4, CATHERINE STREET LONDON, W.C.2

The ONLY VOLUME published DEALING EXHAUSTIVELY with the subject of CONCRETE ROADS.

SECOND EDITION. Entirely rewritten and brought up to date. Fully Illustrated.

CONTAINS COMPLETE SPECIFICATIONS AND METHODS OF CONSTRUCTION OF OVER 200 CONCRETE ROADS IN THIS COUNTRY.

LEADING CONTENTS include: Full particulars of Method of Laying and Useful Notes regarding all Concrete Roads laid in Great Britain, with Official Reports as to their condition, Maintenance Costs, etc.; Concrete Roads in Other Countries; Mechanical Appliances used in Concrete Road Construction; Concrete Kerbs and Channelling; Concrete Pavements; Fence, Telegraph and Lamp Posts, etc.; Hints and Data for Making Concrete and the Choice of Aggregates; a Form of Specification for the Construction of Concrete Roads, etc.

PRESS OPINIONS:

"Embodies the latest practice in this Country." "Of great value to those who desire information."—*Daily Telegraph.*

"Contains a great deal of useful information with regard to methods of construction."—*The Builder.*

"Those who want information as to where concrete roads are laid in this country, and how they are constructed, will find it in the Second Edition of 'Concrete Roads.'"—*Municipal Engineering.*

"Gives in a handy form particulars of methods by which nearly all the concrete roads in Great Britain are laid."—*Municipal Journal.*

Price 5*s.* 6*d.* post free.

"THE BUILDER," LTD.

4, CATHERINE STREET ALDWYCH, W.C.2

THE
PREMIER
ARCHITECTURAL
NEWSPAPER
with the largest SALE amongst
ARCHITECTS

THE
LEADING
CONSTRUCTIONAL
NEWSPAPER
with the largest SALE amongst
BUILDERS & CONTRACTORS

THE BUILDER
A JOURNAL FOR THE
ARCHITECT & CONSTRUCTOR

Every Friday. *Price 9d.*

THE BUILDER contains weekly :

Rates of Wages in the Building Trade for over 150 Districts in England, Scotland and Wales.

"Prices Current" for Materials and "Measured Prices."

The very latest information as to Tenders Accepted and Proposed New Buildings and other works.

The fullest and most-up-to-date list of Contracts Open.

ALL CIRCULATION RECORDS BROKEN DURING 1923.

3 months, post free, 11*s.*
6 months, post free, 21*s.*
12 months, post free, 40*s.*

Avoid Delay by Registering a Regular Order.

A Specimen Copy, price 9d., post free, will be sent on application to

THE BUILDER, Ltd., 4, Catherine Street, Aldwych, W.C.2.

"MUNICIPAL ENGINEERING."

8, BREAMS BUILDINGS LONDON, E.C.4

MUNICIPAL ENGINEERING

IS THE OLDEST
AND HAS THE LARGEST
CIRCULATION OF ANY
MUNICIPAL
ENGINEERING
JOURNAL IN THE
UNITED KINGDOM.

Published Every Thursday.
Price 4d.
Annual Postal Subscription 24/6

IT IS EDITED BY A PRACTICAL MUNICIPAL ENGINEER; HENCE ITS GREAT POPULARITY AND TRUSTWORTHINESS.

CONCRETE AND ITS APPLICATION ARE DEALT WITH FULLY IN EACH ISSUE.

Other Special Features include:—Road Construction and Maintenance; Sewerage and Sewage Disposal; Water Supply; Public Lighting, etc., etc.

Publishers of
THE
EMPIRE MUNICIPAL
DIRECTORY

Which gives all the Corporations, County and District Councils in the United Kingdom, together with their Officials.

Issued Annually.
11/- Post Free in U.K.

MUNICIPAL ENGINEERING

"CONCRETE AND CONSTRUCTIONAL ENGINEERING"

35, GREAT ST. HELENS LONDON, E.C.3

THE ONLY JOURNAL SOLELY DEVOTED TO THE CONCRETE INDUSTRY.

Since its inception in 1906, "CONCRETE AND CONSTRUCTIONAL ENGINEERING" has built up a reputation for its authoritative articles on all phases of the many applications of concrete.

As will be seen from the list on the following page of some of the principal contents during 1923, its contributors include many of the leading men in the industry, and this journal provides the *only* means by which those interested in the concrete industry can keep up to date with current theory and practice.

THE ONLY MEDIUM FOR KEEPING UP-TO-DATE IN CONCRETE THEORY AND PRACTICE.

SPECIAL FEATURES IN EACH ISSUE INCLUDE :

The most complete DATA FOR PRICING REINFORCED CONCRETE WORK published in this country, and a QUESTIONS AND ANSWERS SECTION in which readers' questions and problems are worked out and replied to in detail by experts.

Published Monthly, Price 1*s.* 6*d.* post free ; Annual Subscription, 18*s.* post free.

Editorial Office : 35, Great St. Helens, London, E.C.3 (Avenue 5422).

Publishing Office : 4, Catherine Street, Aldwych, London, W.C.2 (Regent 5940).

"CONCRETE AND CONSTRUCTIONAL ENGINEERING"

35, GREAT ST. HELENS LONDON, E.C.3

[*See also previous page.*]

Some idea of the field covered by "CONCRETE AND CONSTRUCTIONAL ENGINEERING" *may be obtained from the following list of some of the leading Contents during* 1923:—

January—

Destructive Marine Borers, by Gower Pimm, A.M.Inst. C.E.

A Large Ore-Shipping Dock.

American Domestic Architecture.

Reinforced Concrete Cinema.

Concrete Chimney in Pre-cast Segments

Coloured Concrete on the Liverpool Housing Scheme (with Coloured Plates).

February—

New Column and Beam Testing Machine, by H. E. Lance Martin, B.Sc., A.M.Inst.C.E.

Reinforced Concrete and Fire Resistance, by J. Singleton-Green, B.Sc., A.M.M.C.I.

Concrete Bridges without Centering.

March—

The Design of Steel-Frame Buildings, by Ewart S. Andrews, B.Sc., M.Inst.C.E.

Reinforced Concrete Pumping Station at Aberdeen, by James Mitchell, M.Inst.C.E.

Extensions at Tilbury Docks.

April—

American Methods in Concrete Work, by Albert Lakeman, M.S.A.

Proportioning Concrete Mixtures.

May—

Moments in Continuous Beams for Varying Ratios of Live Load to Dead Load, by Charles S. Gray, B.Sc.

Concrete Roads, by F. Wilkinson, M.Inst.C.E.

June—

Wind: Its Effects upon Structures, by H. F. Cornick, A.M.Inst.C.E.

Reinforced Concrete Schemes in the Limfjord Bridge Competition.

Surface Treatments for Concrete.

July—

Reinforced Concrete Bowstring Bridge at Nantes, by W. L. Scott, A.M.Inst.C.E.

Silicate of Soda and Concrete, by L. A. Munro, B.A., F.I.C.

New Waterworks at Aberdeen.

August—

Structural Steelwork Reinforced with Concrete, by Ewart S. Andrews, B.Sc., M.Inst.C.E.

Behaviour of Concrete under the Action of Torsion.

Reinforced Concrete Grand Stand at Blackheath.

Estimating for Concrete Work.

September—

The Increase in Strength of Short Concrete Columns due to Helical Reinforcement, by W. D. Womersley, M.A., B.Sc., Wh.Sc., A.M.Inst.C.E.

Combined Chimney and Water Tank.

Restoring Concrete injured by Electrolysis.

New Method of Driving Concrete Piles.

Shear Tests in Arched Beams.

October—

Reinforced Concrete Grain Silos at Avonmouth.

Concrete Houses in Holland.

Alignment Chart for the Design of Reinforced Concrete Slabs, by H. M. Gibb.

Concrete Railway Sleepers in India.

Torsional Strength of Rectangular Concrete Sections.

November—

Concrete Tubes for Internal Pressure, by Dr. F. Emperger.

Reinforced Concrete in Reservoir Construction, by E. R. Matthews, M.Inst.C.E.

Reinforced Concrete Road Bridges.

December—

Simple Examples of Reinforced Concrete Design. By Oscar Faber, O.B.E., D.Sc.

The "Duo-Slab" System of Cottage Construction.

Strength of Short Concrete Beams, by J. B. Macphail, B.Sc., A.M.E.I.C.

THE MUNICIPAL JOURNAL, LTD.
SARDINIA HOUSE, SARDINIA STREET LONDON, W.C.2

THE MUNICIPAL JOURNAL

First with the news and latest developments.

The leading paper of the service, which is read by all the principal Local Government Officers.

Weekly.

Threepence.

THE MUNICIPAL YEAR BOOK

Invaluable to Contractors, Manufacturers and Merchants wishing to do business with Municipal Authorities.

It gives the names of the principal officers of all the Municipal Corporations, County Councils, Urban District Councils, Rural District Councils, the principal Scottish and Irish Cities and Towns, Joint Water and Gas Authorities, Port Sanitary Authorities, Joint Sewerage Authorities and Joint Hospital Authorities.

Price 15s. nett.
Post Free, 16s.

"ROADS AND ROAD CONSTRUCTION."
CARRIERS PUBLISHING CO., LTD. 83-5, FARRINGDON STREET, E.C.4

ROADS AND Road Construction

A MONTHLY
RECORD
of
ROAD
ENGINEERING
and
DEVELOPMENT.

A Paper for the
Surveyor,
Road Engineer,
and all interested
in Road Construction.

Subscription :
12 Shillings per annum.

Regular Features Each Month :—

Road Improvement Schemes (Approved)

Foreign Road Construction Notes

Road Makers of To-day.

Particulars of New Patents.

A Review of Road Materials and Plant (including Transport Vehicles).

News from all Parts.

New Companies.

Phone : City 3778.

ROADS AND Road Construction

ALPHABETICAL INDEX TO CATALOGUE SECTION.

PAGE

Alexander, Herbert, & Co., Ltd. 254
Allied Machinery Co., Ltd. 252–3
Anglo-Danish Concrete Construction Co., Ltd. 225
Associated Portland Cement Manufacturers, Ltd. . . . 201
Atlas Diesel Co., Ltd. 255
Bain & Brown, Ltd. 226
Bedfordshire Tile Co., Ltd. 277
Bevis, Frank, Ltd. 227
Birmingham Concrete Steel Co. 228
Bradshaw's Reinforced Concrete Co., Ltd. 278–9
Bristol Concrete Co., Ltd. 280
British Portland Cement Manufacturers, Ltd. 202
British Standard Cement Co., Ltd. 203
British Steel Piling Co. 272–3
Brown & Tawse, Ltd. 313
Brunner, Mond & Co., Ltd. 302–3
"Builder, The" 327
Building Products, Ltd. 304
Burn Bros. (London), Ltd. 318
Buxton Lime Firms Co., Ltd. 305
Byrd, A. A., & Co. 256–8
Cement Industries . 204–7, 220, 222, 248–9, 251, 282–5, 306
Cement Marketing Co., Ltd. 208–9
Chalmers-Edina Co. 259

INDEX TO CATALOGUE SECTION

PAGE

Chapman & Hall, Ltd. 320–1
Child, H. J. 188
Coignet, Edmond, Ltd. 229
Columbian Fireproofing Co., Ltd. 245
"Concrete & Constructional Engineering" . . . 329–30
Concrete Industries, Ltd. 286
Concrete Manufacturers (No. 1 London), Ltd. . . . 288–9
Concrete Piling, Ltd. 274
Concrete Publications, Ltd. 230, 326, 329–30
"Concrete Roads" 326
Concrete Supply & Marketing Co., Ltd. 287
Concrete Utilities Bureau 281, 296, 312
Cowan Hulbert 260
Craig-Lelo Quarry Co., Ltd. 290
Cullum, Horace W., & Co., Ltd. 246
Cyclops Concrete Co. 261
Dee-Clwyd Granite Quarries Co., Ltd. 189
Dundee Sand & Lighterage Co., Ltd. 190
Earle, G. & T., Ltd. 210
Eternit Pietra Artificiale (London), Ltd. 199
Evans Bros. 291
Expanded Metal Co., Ltd. 314–5
Fowler, John, & Co. (Leeds), Ltd. 262
Gilchrist, Alexander 263
Glarea, Ltd. 191
Gloucester Concrete Construction Co., Ltd. 292
Greaves, Bull & Lakin, Ltd. 211
Helical Bar & Engineering Co., Ltd. 316
Hillhouse Quarry Co. 192
Holst, K., & Co. 231
Industrial Constructions, Ltd. 232–3

PAGE

Jackaman, A., & Son, Ltd. 234
Kirk & Randall, Ltd. 235
Lill, Henry 293
Lind, Peter, & Co. 236
Lindum Stone Co. 294–5
Liverpool Artificial Stone Co., Ltd. 297
McGraw-Hill Publishing Co., Ltd. 322–5
Martin, Earle & Co., Ltd. 212
Monnoyer British Construction Co., Ltd. 237
"Municipal Engineering" 328
"Municipal Journal," Ltd. 331
Nelson, Charles, & Co., Ltd., ... 213
North London Ballast & Sand Co., Ltd. 193
Parker, Winder & Achurch, Ltd. 264
Peters, C. A., Ltd. 194, 221, 223, 307
Potter, F. W., & Co. 200
Ransome Machinery Co., (1920), Ltd. 265
Redhill Tile Co., Ltd. 298–9
R.I.W. Protective Products Co., Ltd. . . . 224, 271, 309–10
"Roads and Road Construction" 332
Sandhills Co. 195
Saxild & Partners 238–9
Scott, Andrew 240
Ship Canal Portland Cement Co., Ltd. 214–5
Sidney Trade Illustrations Co. 319
Simplex Concrete Piles, Ltd. 275
Slate Industries, Ltd. 308
Snettisham Shingle Co., Ltd.. 196
South Wales Portland Cement & Lime Co., Ltd. . . . 216
Stancliffe Estates Co., Ltd. 197
Stewart, J. & W. 247, 276

INDEX TO CATALOGUE SECTION

	PAGE
Stothert & Pitt, Ltd.	266–7
Super-Cement, Ltd.	217
Toch Bros.	224, 271, 309–10
Topping & Leggat	241
Torbay & Dart Paint Co., Ltd.	311
Trent Concrete, Ltd.	300
Verdura Hard Court Co.	250
Wait, Edwin	242
Walker, J. H., & Co.	198
Wellerman Bros., Ltd.	243
Wharf Lane Concrete Co., Ltd.	301
Whitson & Co.	270
Winget Ltd.	268–9
Wire Tie Co.	317
Woolley, James, Sons & Co., Ltd.	219
Worthington, W. H., Ltd.	244
Wouldham Cement Co., Ltd.	218

Printed in Great Britain by Butler & Tanner Ltd., *Frome and London*

UNIVERSITY OF ILLINOIS-URBANA
3 0112 047374811